JOHNSON'S

HANDY MANUAL

FOR

PLUMBERS AND PIPE FITTERS

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CHICAGO

Dedication

TO THE PIPE FITTERS AND PLUMBERS,

WITH WHOM I HAVE SPENT
SO MANY PLEASANT YEARS,
I DEDICATE THIS MANUAL.

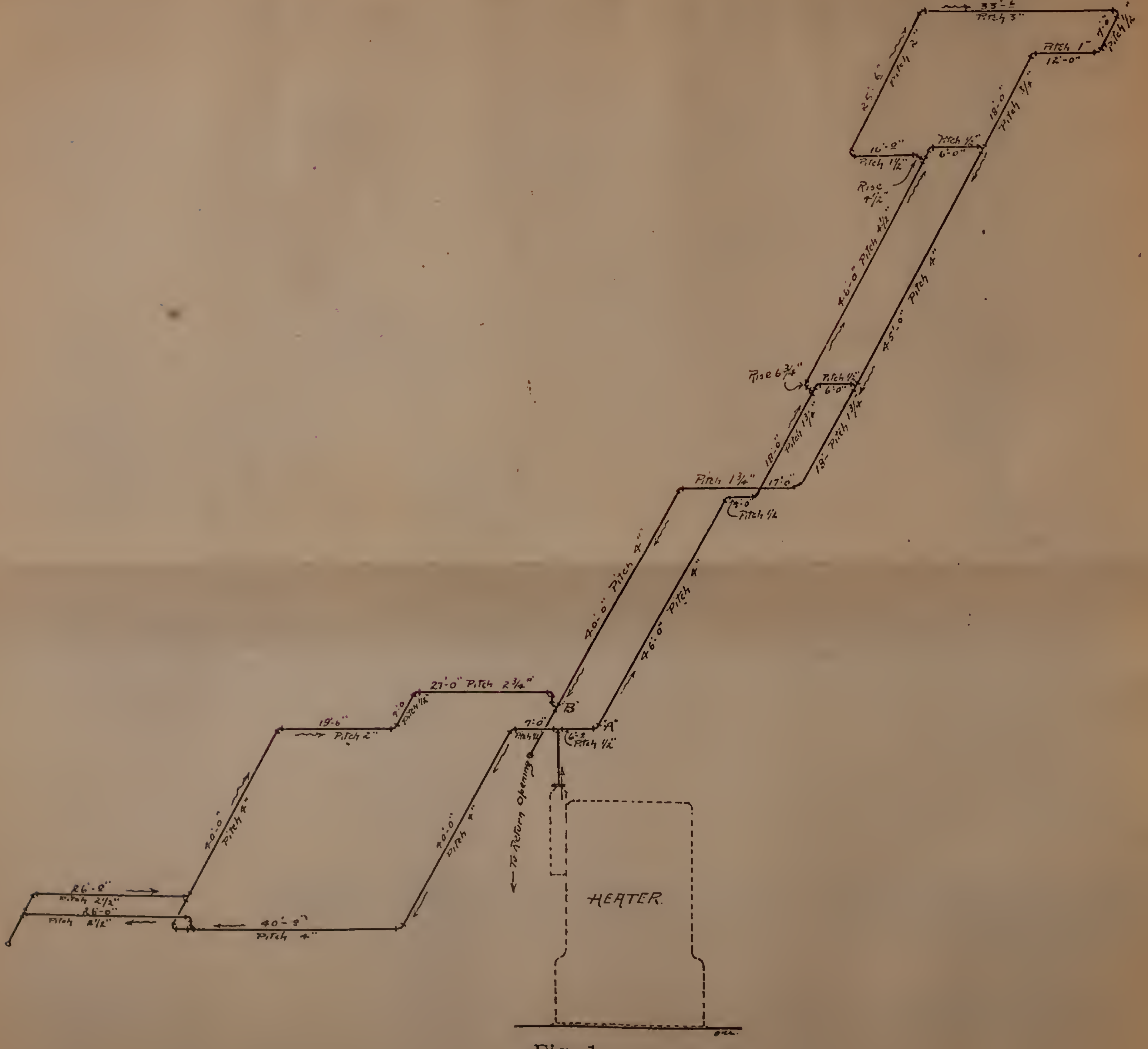

33'-6"
Pitch 3"
7'-0"
Pitch 1/2"
Pitch 1"
12'-0"
25'-6" Pitch 2"
18'-0" Pitch 3/4"
10'-0"
Pitch 1 1/2"
Pitch 1/2"
6'-0"
Rise 4 1/2"
46'-0" Pitch 4 1/2"
45'-0" Pitch 4"
Rise 6 3/4"
Pitch 1/2"
6'-0"
18'-0" Pitch 1 3/4"
18'- Pitch 1 3/4"
Pitch 1 3/4"
17'-0"
13'-0"
Pitch 1/2
40'-0" Pitch 4"
46'-0" Pitch 4"
27'-0" Pitch 2 3/4"
7'-0 Pitch 1/2"
19'-6"
Pitch 2"
B
7'-0"
Pitch 1/2"
A
6'-0
Pitch 1/2"
To Return Opening
40'-0" Pitch 4"
40'-0" Pitch 4"
26'-0"
Pitch 2 1/2"
26'-0"
Pitch 2 1/2"
40'-9"
Pitch 4"
HEATER.

Fig. 1.

How to Construct Long Horizontal Flow Mains in Hot Water Heating Plants.

In constructing hot water heating plants for scattered buildings, where all radiation is supplied from one boiler, or a group of boilers coupled together, there must be some careful calculations made in the laying out of pipe work in order to secure a good circulation at all points throughout the plant. And, for the purpose of showing how this can be done in a successful manner, we make use of plate Fig. 1, which is the working drawing of a large hot water heating plant now in operation and giving the most satisfactory results.

We merely show in plate Fig. 1, the cellar mains connected to the boiler, but branches are taken from top of flow lines to the various radiators and risers with returns carried back to side of same flow lines.

Referring to the plan, it will be observed that the main flow from boiler connects with a Tee which separates the flow water to each side of the boiler as it is located. This Tee is the highest point in the cellar system of main pipes. We will now follow the flow line on the right, marked (A). The direction of the arrow will show the direction in which the water moves. The first Tee over the boiler being the highest point, we begin to pitch down from this point, and, as will be noticed, in a distance of 6 feet we have a fall of $\frac{1}{2}$ inch to the first angle or elbow. We have now a run of 46 feet, and in this distance we pitch down 4 inches. We now come to a bend in the line which is 5 feet long and we give this a $\frac{1}{2}$ inch pitch. The next long stretch is 18 feet, which is given $1\frac{3}{4}$ inch pitch. At this point we place a Tee on the line with the outlet looking up, with the end of this Tee connecting by a 6 foot piece of main pipe to the side of the return, as shown. This offset is pitched $\frac{1}{2}$ inch, which practically completes the first circuit.

It will now be noticed as far as we have gone with this main flow line to the first Tee looking up, we have dropped 6¾ inches, and to continue further horizontally we rise from top of Tee just described, the same distance which we pitched down from boiler, 6¾ inches, then extending the main flow line, as will be noticed, a distance of 46 feet more, with a pitch in this distance of 4½ inches, connecting with another Tee, we rise again the distance which we dropped in the last run, which is 4½ inches, and, connecting the end of Tee to the side of return pipe, thus completing a second circuit in the main lines.

The main flow line is pitched down again from the last 4½ inch rise as indicated, making the last circuit on the extreme end of the system and gradually pitching back to the return connection of boiler. (B) represents the main return pipe in the system, and, referring again to the pipe work on the left of boiler, the same general method is carried out, forming separate circuits according to the distance and conditions of the building, yet with only one flow and one return pipe connecting with the boiler. It is advisable to place air valves or air pipes at all high points on main flow lines, so that any air that may accumulate at such points, can be drawn or allowed to escape.

This system of dividing the main flow line into various circuits gives a more uniform distribution of the hot water to the radiation, and allows the coldest water in the system to move back more rapidly to the boiler, by not having to travel the entire distance of the flow line.

In pipe systems as shown in Fig. 1, the proportioning of the size of the pipes at the various points for the work to be performed, is also an important matter, and long sweep fittings only should be used.

Table Showing Size of Chimneys with Approximate Horse Power Boiler.

COMMERCIAL HORSE POWER.											Effective Area, Square Feet.	Actual Area Square Feet.	Side of Square of Approximate Area, Inches.
50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
23	25	27	....	....	......	......	......	......	......	......	0.97	1.77	16
35	38	41	....	....	......	......	......	......	......	......	1.47	2.41	19
49	54	58	62	....	......	......	......	......	......	......	2.08	3.14	22
65	72	78	83	....	......	......	......	......	......	......	2.78	3.98	24
84	92	100	107	113	......	......	......	......	......	......	3.58	4.91	27
....	115	125	133	141	......	......	......	......	......	......	4.47	5.94	30
....	141	152	163	173	182	......	......	......	......	......	5.47	7.07	32
....	....	183	196	208	219	......	......	......	......	......	6.57	8.30	35
....	....	216	231	245	258	271	......	......	......	......	7.76	9.62	38
....	....	....	311	330	348	365	389	......	......	......	10.44	12.57	43
....	....	....	363	427	449	472	503	551	......	.....	13.51	15.90	48
....	....	....	505	539	565	593	632	692	748	......	16.98	19.64	54
....	....	....	....	658	694	728	776	849	918	981	20.83	23.76	59
....	....	....	....	792	835	876	934	1023	1105	1181	25.08	28.27	64
....	....	....	....	....	995	1038	1107	1212	1310	1400	29.73	33.18	70
....	....	....	....	....	1163	1214	1294	1418	1531	1637	34.76	38.48	75
....	....	....	....	...	1344	1415	1496	1639	1770	1893	40.19	44.18	80
....	....	....	....	....	1537	1616	1720	1876	2027	2167	46.01	50.27	86

An Easy and Correct Method of Ascertaining Length of Pipe Required in 45° Angles.

In the pipe fitting of steam and hot water heating plants, 45 degree elbows are brought into use extensively, and it is not every mechanic who has mastered mathematics sufficiently to be able to figure square root in order to find the hypotenuse of an angle, and on this account we give the following methods of getting the measurements of 45 degree angles, which is approximately correct for pipe use.

For each inch of offset add $^{53}/_{128}$ of an inch and the result will be the distance from center to center of the 45 degree angle.

For instance: Referring to illustration, Fig. 3, we will suppose that a pipe is to be brought up from a lower floor near a wall, and it is to pass through the ceiling of a room at a distance of 20 inches farther away from the wall than that which it rises through the floor, as indicated in the illustration by the figures, 20 inches, which is shown by the plumbob. This

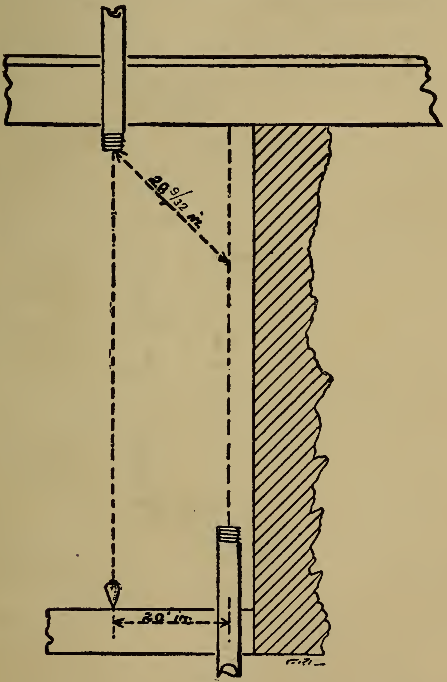


Fig. 2.

shows that the distance in a straight line from center to center of the two points is 20

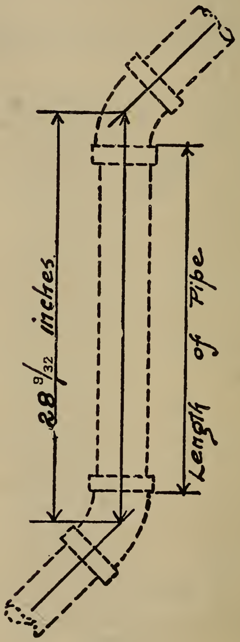


Fig. 3.

inches. Now it is simply necessary to add to the 20 inches 20 times 53, and divide the result by 128, to get the additional length necessary for the 45 degree angle. Thus:— $20\times53=1060$, $1060\div128=8^{9}/_{32}$, which added to the 20 inches, makes the distance of the angle, as shown, $28^{9}/_{32}$ inch.

In any case it will be necessary to allow for the distance taken up by the fittings from center to center of same, as shown in Fig. 3.

By this system it will make no difference how many inches the offset may be; simply add for each inch an additional fraction of $^{53}/_{128}$ of an inch. Again, suppose the offset is to be 5 inches, we multiply 5 by 53, which gives us 265. We now divide the 265 by 128, which gives us $2^{1}/_{16}$; this result we now add to 5 inches, which is the distance of offset, and we have $7^{1}/_{16}$ inches from center to center of the 45 degree angle. Any distance may be obtained in the same manner.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides.		Diagonal.		Sides.		Diagonal.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
	1		1⁷⁄₁₆	1	10	2	7⅛
	2		2¹³⁄₁₆	1	11	2	8½
	3		4¼	2		2	9¹⁵⁄₁₆
	4		5⅝	2	1	2	11⅜
	5		7¹⁄₁₆	2	2	3	¾
	6		8½	2	3	3	2³⁄₁₆
	7		9⅞	2	4	3	3⁵⁄₁₆
	8		11⁵⁄₁₆	2	5	3	5
	9		12¾	2	6	3	6⁷⁄₁₆
	10	1	2⅛	2	7	3	7¹³⁄₁₆
	11	1	3⁹⁄₁₆	2	8	3	9¼
	12	1	5	2	9	3	10¹¹⁄₁₆
1	1	1	6⅜	2	10	4	¹⁄₁₆
1	2	1	7¹³⁄₁₆	2	11	4	1½
1	3	1	9³⁄₁₆	3		4	2¹⁵⁄₁₆
1	4	1	10⅝	3	1	4	4⁵⁄₁₆
1	5	2	¹⁄₁₆	3	2	4	5¾
1	6	2	1⁷⁄₁₆	3	3	4	7³⁄₁₆
1	7	2	2⅞	3	4	4	8⁹⁄₁₆
1	8	2	4⁵⁄₁₆	3	5	4	10
1	9	2	5¹¹⁄₁₆	3	6	4	11⅜

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides. Ft.	In.	Diagonal. Ft.	In.	Sides. Ft.	In.	Diagonal. Ft.	In.
3	7	5	13/16	5	4	7	6½
3	8	5	2¼	5	5	7	7 15/16
3	9	5	3⅝	5	6	7	9 5/16
3	10	5	5 1/16	5	7	7	10¾
3	11	5	6 7/16	5	8	8	3/16
4		5	7⅞	5	9	8	1 9/16
4	1	5	9 5/16	5	10	8	3
4	2	5	10 11/16	5	11	8	4 7/16
4	3	6	⅛	6		8	5 13/16
4	4	6	1 9/16	6	1	8	7¼
4	5	6	2 15/16	6	2	8	8⅝
4	6	6	4⅜	6	3	8	10 1/16
4	7	6	5¾	6	4	8	11½
4	8	6	7 3/16	6	5	9	⅞
4	9	6	8⅝	6	6	9	2 5/16
4	10	6	10	6	7	9	3¾
4	11	6	11 7/16	6	8	9	5⅛
5		7	⅞	6	9	9	6½
5	1	7	2¼	6	10	9	7 15/16
5	2	7	3 11/16	6	11	9	9⅜
5	3	7	5 1/16	7		9	10 13/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides.		Diagonal.		Sides.		Diagonal.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
7	1	10	3/16	8	10	12	5⅞
7	2	10	1⅝	8	11	12	7 5/16
7	3	10	3	9		12	8¾
7	4	10	4 7/16	9	1	12	10⅛
7	5	10	5⅞	9	2	12	11 9/16
7	6	10	7¼	9	3	13	1
7	7	10	8 11/16	9	4	13	2⅜
7	8	10	10⅛	9	5	13	3 13/16
7	9	10	11½	9	6	13	5¼
7	10	11	15/16	9	7	13	6⅝
7	11	11	2⅜	9	8	13	8 1/16
8		11	3¾	9	9	13	9 7/16
8	1	11	5 3/16	9	10	13	10⅞
8	2	11	6⅝	9	11	14	5/16
8	3	11	8	10		14	1 11/16
8	4	11	9 7/16	10	1	14	3⅛
8	5	11	10 13/16	10	2	14	4 9/16
8	6	12	¼	10	3	14	5 15/16
8	7	12	1 11/16	10	4	14	7⅜
8	8	12	3 1/16	10	5	14	8¾
8	9	12	4½	10	6	14	10 3/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides.		Diagonal.		Sides.		Diagonal.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
10	7	14	11 5/8	12	4	17	5 5/16
10	8	15	1	12	5	17	6 11/16
10	9	15	2 7/16	12	6	17	8 1/8
10	10	15	3 7/8	12	7	17	9 9/16
10	11	15	5 1/4	12	8	17	10 15/16
11		15	6 11/16	12	9	18	3/8
11	1	15	8 1/16	12	10	18	11 13/16
11	2	15	9 1/2	12	11	18	3 3/16
11	3	15	10 15/16	13		18	4 5/8
11	4	16	3/8	13	1	18	6
11	5	16	1 3/4	13	2	18	7 7/16
11	6	16	3 3/16	13	3	18	8 7/8
11	7	16	4 9/16	13	4	18	10 1/4
11	8	16	6	13	5	18	1 11/16
11	9	16	7 3/8	13	6	19	1 1/8
11	10	16	8 13/16	13	7	19	2 1/2
11	11	16	10 1/4	13	8	19	3 15/16
12		16	11 5/8	13	9	19	5 5/16
12	1	17	1 1/16	13	10	19	6 3/4
12	2	17	2 7/16	13	11	19	8 3/16
12	3	17	3 7/8	14		19	9 9/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides.		Diagonal.		Sides.		Diagonal.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
14	1	19	11	15	10	22	4 11/16
14	2	20	7/16	15	11	22	6 1/8
14	3	20	1 13/16	16		22	7 1/2
14	4	20	3 1/4	16	1	22	8 15/16
14	5	20	4 11/16	16	2	22	10 3/8
14	6	20	6 1/16	16	3	22	11 3/4
14	7	20	7 1/2	16	4	23	1 3/16
14	8	20	8 7/8	16	5	23	2 5/8
14	9	20	10 5/16	16	6	23	4
14	10	20	11 3/4	16	7	23	5 7/16
14	11	21	1 1/8	16	8	23	6 13/16
15		21	2 9/16	16	9	23	8 1/4
15	1	21	4	16	10	23	9 11/16
15	2	21	5 3/8	16	11	23	11 1/16
15	3	21	6 13/16	17		24	1/2
15	4	21	8 3/16	17	1	24	1 15/16
15	5	21	9 5/8	17	2	24	3 5/16
15	6	21	11 1/16	17	3	24	4 3/4
15	7	22	7/16	17	4	24	6 1/8
15	8	22	1 7/8	17	5	24	7 9/16
15	9	22	3 5/16	17	6	24	9

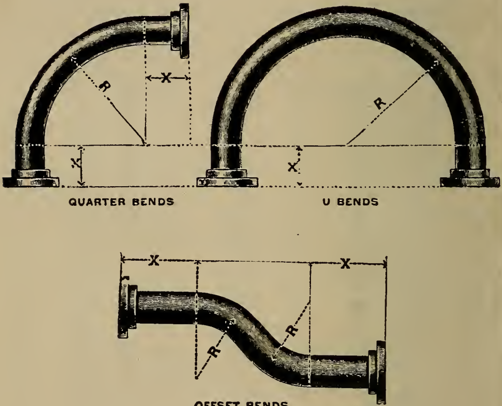
Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides.		Diagonal.		Sides.		Diagonal.	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
17	7	24	10 3/8	18	10	26	7 5/8
17	8	24	11 13/16	18	11	26	9
17	9	25	1 1/4	19		26	10 7/16
17	10	25	2 5/8	19	1	26	11 7/8
17	11	25	4 1/16	19	2	27	1 1/4
18		25	5 1/2	19	3	27	2 11/16
18	1	25	6 7/8	19	4	27	4 1/16
18	2	25	8 5/16	19	5	27	5 1/2
18	3	25	9 11/16	19	6	27	6 15/16
18	4	25	11 1/8	19	7	27	8 5/16
18	5	26	9/16	19	8	27	9 3/4
18	6	26	1 15/16	19	9	27	11 3/16
18	7	26	3 3/8	19	10	28	9/16
18	8	26	4 13/16	19	11	28	2
18	9	26	6 3/16	20		28	3 7/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Illustration showing how to obtain measurements of all kinds of bends used in heavy duty work.



QUARTER BENDS

U BENDS

OFFSET BENDS

Fig. 4.

The radius of any bend should not be less than 5 diameters of the pipe and a larger radius is much preferable. The length "X" of straight pipe at each end of bend should be not less than as follows:

2½-in. Pipe X=4 in.
3 -in. Pipe X=4 in.
3½-in. Pipe X=5 in.
4 -in. Pipe X=5 in.
4½-in. Pipe X=6 in.
5 -in. Pipe X=6 in.
6 -in. Pipe X=7 in.
7-in. Pipe X= 8 in.
8-in. Pipe X= 9 in.
10-in. Pipe X=12 in.
12-in. Pipe X=14 in.
14-in. Pipe X=16 in.
15-in. Pipe X=16 in.
16-in. Pipe X=20 in.
18-in. Pipe X=22 in.

Table showing expansion of iron pipe for each 100 feet in inches from 30 degrees.

Temperature.	Expansion in inches.
165 degrees.	1.15
215 degrees.	1.47
265 degrees.	1.78
297 degrees.	2.12
338 degrees.	2.45

Radiation in Low Pressure Steam Heating Plant Below Water Line of Boiler.

There are two ways by which heat may be had from low pressure steam heating plants at points below the water level of the boiler, and while these two special points are known to the average fitter, there are many persons practicing this line of trade who have had no experience with such system, but who often meet situations where radiation below the water line would be desirable. The illustration, Fig. 5, will serve to show how the pipe work of such radiation may be practically carried out. In the illustration B represents the steam boiler, from which steam may be carried to the various radiators situated above the boiler and having the usual return pipe to bring back the condensation to the boiler.

The highest point to which water rises, or the water level, is indicated by W, and on the right side of boiler is a return bend coil, all of which is situated below the water level, and

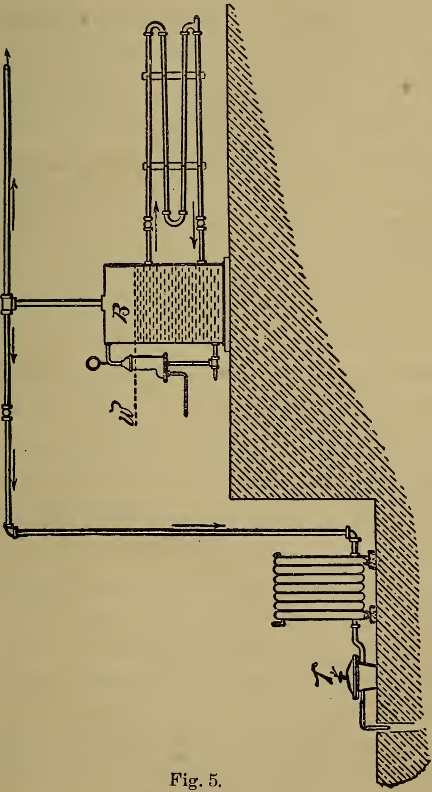


Fig. 5.

which can be used as radiating surface. Through this coil the water from the steam boiler can be made to circulate, and will be found to be very effective. Both connections of the coil should be provided in such cases with valves as shown, and while one valve would answer the purpose of stopping the circulation, it is always best to provide against a leak in the coil, so that a valve in each branch to the boiler might save trouble and annoyance. Then where such radiation as shown on the right of boiler is used, provision should always be made to drain the coils of water when not wanted for heating purposes in cold weather, and this can be done by placing a pet cock at some point on the lower pipe in such coil. If the pipes to hot water radiation of this kind are carried as shown, there will be no necessity of air valves, as all air will pass to the boiler and escape through radiators situated at some higher elevation.

Any style of hot water radiation can be used for such purposes, as well as pipe coils, by simply carrying out the same general principle of producing circulation. On the left of the boiler in the illustration is shown another kind of radiation at a point below the boiler, and in this case steam is used, but the condensation does not return to the boiler, and therefore provision is made in this case so that there will be no escapement of steam and at the same time completely draining the radiator. At the outlet end of this style radiation is placed a steam trap, as indicated by T, the discharge pipe from which connects with a waste or drain pipe. There are a few special points connected with this arrangement of radiation, which must also be remembered, to guard against damage from freezing. And, as will be noticed, the radiation is elevated so that all water will fall from it into the steam trap by gravitation, then, again, the one valve for controlling the supply of steam to this radiator is located near the main steam pipe above the boiler, so that at times when this valve is closed there will be no chance for water to stand in any part of the steam pipe to the radiator where it might freeze. An automatic air valve will be necessary on such radiators in order to keep up a circulation of the steam at all times during cold weather, for the reason that it would be possible to stop circulation by the accumulation of air in the radiator with an ordinary direct air valve, and with the steam supply valve on main pipe wide open, and under such circumstances it would be possible for the water to freeze in the steam trap, thus closing the outlet and allowing the radiator and all connections to it to fill with water. Therefore it will be seen that this is a very important place to use the best make of automatic air valves. In regard to the supply valves on all lines, if globe valves are used, they should be placed at an angle of 45 degrees, as shown in illustration, in order to prevent trapping of these lines, but gate valves in such places may be placed at any angles. In heating systems of this kind where steam radiation is located below the water level of the boiler and condensation from such surface discharged through steam traps, there will be a loss of water from the boiler to the extent of such condensation, and on this account, it will be necessary to place on the boiler a reliable automatic water feeder connected to the water service supply to keep the water up to its proper height in the boiler at all times, and not alone to save attention but to protect the boiler.

What a Unit of Heat is.

A unit of heat is that amount of heat which is required to raise the temperature of one pound of water 1 degree F., and is used to calculate and measure the quantity of heat.

Combustion of Fuel in House-Heating Boilers.

The combustion of fuel in any given area of grate must depend on the rapidity of the draught.

In ordinary home heating boilers, one square foot of grate will burn from 5 to 8 pounds of coal per hour.

One pound of coal should add about 9000 heat units to water in a boiler used for heating purposes.

One cubic foot of ordinary coal gas contains 650 units of heat, but 50 % of this is lost in the generating of steam or heating of water by even the best construction of Bunsen or atmospheric burners, so that 1 cubic foot of 16 candle power gas will add about 325 units of heat to water below 200 degrees F.

A most important thing in the construction of steam heating plants, is to properly proportion the boiler, the grate surface with the heating surface, also the proper area of chimney for a proper and economical consumption of the fuel, and for this purpose the following diagrams have been arranged, and which are the result of practical experience and tests under various conditions.

It will be noticed in referring to plate, Fig. 6, that one square foot of grate surface will supply 36 square feet of boiler surface; and this amount of grate and boiler surface will carry 196 square feet of direct radiating surface for heating purposes. The area of chimney must be taken into consideration, and for this amount we allow 49 square inches.

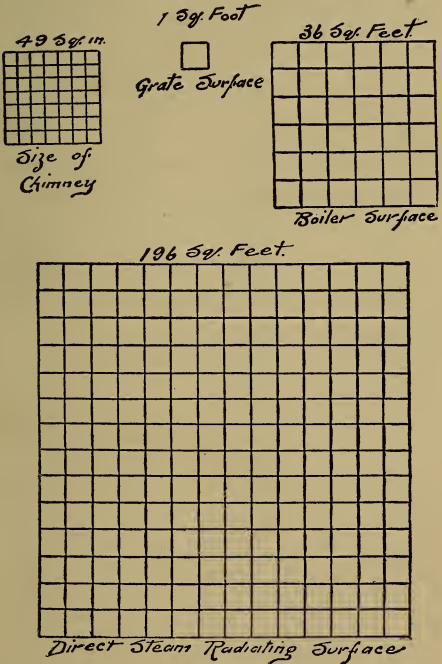


Fig. 6.

Chimney Flues.

For low pressure gravity steam heating plants, carrying over 1000 feet of radiation, the size of chimney may be reduced somewhat less in proportion than that shown in Fig. 5. The success of any heating plant depends largely on the chimney, and no matter how well a boiler may be proportioned and constructed, there cannot be proper results unless the chimney is also properly constructed. Chimneys intended for heating plants should never be constructed less than 8x8 inches in the clear for the smallest size private house.

Table showing number of brick required for bricking various sizes of tubular boilers.

Inches.	Feet.	Common Brick.	Fire Brick.
30	8	5110	320
30	10	5710	320
36	8	6100	480
36	10	6900	480
40	10	7530	600
40	12	8630	600
42	10	9380	720
42	12	10630	720
42	14	11430	720
48	12	13000	980
48	14	14000	980
48	16	15000	980
54	14	14520	1154
54	16	15720	1154
60	14	15780	1280
60	16	17080	1280
60	18	18380	1280
66	16	19350	1400
66	18	20650	1400
72	16	20350	1550
72	18	21550	1550

Table of relative sizes of one pipe steam main showing feet of radiation pipe will take care of.

1 inch.....	40 to	50 Feet of Radiation.
1¼ inch.....	100 to	125 Feet of Radiation.
1½ inch.....	125 to	250 Feet of Radiation.
2 inch.....	250 to	400 Feet of Radiation.
2½ inch.....	400 to	650 Feet of Radiation.
3 inch.....	650 to	900 Feet of Radiation.
3½ inch.....	900 to	1250 Feet of Radiation.
4 inch.....	1250 to	1600 Feet of Radiation.
4½ inch.....	1600 to	2050 Feet of Radiation.
5 inch.....	2050 to	2500 Feet of Radiation.
6 inch.....	2500 to	3600 Feet of Radiation.
7 inch.....	3600 to	5000 Feet of Radiation.
8 inch.....	5000 to	6500 Feet of Radiation.
9 inch.....	6500 to	8100 Feet of Radiation.
10 inch.....	8100 to	10000 Feet of Radiation.

Table showing various size of pipe constituting a foot of Radiation.

Water and steam the same.

36 in. 1 in. pipe makes 1 foot of radiation.
28 in. 1¼ in. pipe makes 1 foot of radiation.
24 in. 1½ in. pipe makes 1 foot of radiation.
20 in. 2 in. pipe makes 1 foot of radiation.
16 in. 2½ in. pipe makes 1 foot of radiation.
13 in. 3 in. pipe makes 1 foot of radiation.
11 in. 3½ in. pipe makes 1 foot of radiation.
10 in. 4 in. pipe makes 1 foot of radiation.
7 in. 5 in. pipe makes 1 foot of radiation.
4 in. 6 in. pipe makes 1 foot of radiation.

Heating Surface of Boilers.

In considering the question, "What is good and proper heating surface in steam boilers?" we take the horizontal tubular style of boilers as the standard, and any construction of cast or wrought iron boiler with as good heating surface may be figured in the same manner as to capacity.

Horizontal Tubular Boilers.

Diam of Shell	Length of Shell	No. of Tubes	Diam. of Tubes	Length of Tubes	Gauge of Shell	Gauge of Heads	Heat'g Surface	Horse Pow'r
60	19	65	3½	18	⅜	½	1147	76
60	18	65	3½	17	⅜	½	1074	72
60	17	65	3½	16	⅜	½	1006	67
60	17	92	3	16	⅜	7/16	1229	82
60	16	92	3	15	⅜	7/16	1152	77
60	15	92	3	14	⅜	7/16	1075	72
60	14	92	3	13	⅜	7/16	998	67
54	19	50	3½	18	5/16	½	951	63
54	18	50	3½	17	5/16	½	900	60
54	17	50	3½	16	5/16	½	795	53
54	17	72	3	16	5/16	7/16	977	65
54	16	72	3	15	5/16	7/16	917	61
54	15	72	3	14	5/16	7/16	857	57
54	14	72	3	13	5/16	7/16	797	53
54	13	72	3	12	5/16	7/16	735	49
48	17	40	3½	16	5/16	⅜	683	46
48	17	49	3	16	5/16	⅜	684	46
48	16	49	3	15	5/16	⅜	642	43
48	15	49	3	14	5/16	⅜	600	40
48	14	49	3	13	5/16	⅜	555	37
48	13	49	3	12	5/16	⅜	513	34
48	12	65	2½	11	5/16	⅜	542	36
42	16	38	3	15	¼	⅜	508	34
42	15	38	3	14	¼	⅜	476	32
42	14	38	3	13	¼	⅜	441	30
42	13	38	3	12	¼	⅜	408	27
42	12	45	2½	11	¼	⅜	390	26
42	11	45	2½	10	¼	⅜	355	24
42	10	45	2½	9	¼	⅜	320	22
42	9	45	2½	8	¼	⅜	285	19
42	8	45	2½	7	¼	⅜	248	16
36	13	28	3	12	¼	⅜	306	20
36	12	34	2½	11	¼	⅜	298	20
36	11	34	2½	10	¼	⅜	271	18
36	10	34	2½	9	¼	⅜	244	16
36	9	34	2½	8	¼	⅜	211	14
36	8	34	2½	7	¼	⅜	190	12
30	9	30	2	8	¼	⅜	152	10
30	8	30	2	7	¼	⅜	133	8
30	7	30	2	6	¼	⅜	114	7
30	6	30	2	5	¼	⅜	95	6

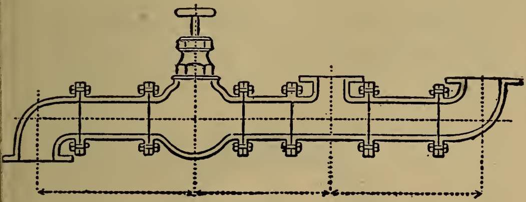


Fig. 7.

How to Properly Take Measurements of Pipes and Fittings.

In Fig. 7, we give a diagram of two elbows, a valve, and a tee, with lines drawn through the center of each fitting, also a lateral line below with arrows indicating the center points of fittings, inside of which the measurements are to be marked. This makes it clear when ordering pipe work with fittings cut to order, so that if the measurements are correctly taken and placed on diagram, there can be no mistakes in getting out such work.

Outside diameter of standard wrought iron steam, gas and water pipe. From $\frac{1}{8}$ to 10 inches.

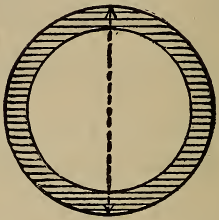


Fig. 8.

Size of pipe..........	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside diam. of pipe	$\frac{40}{100}$	$\frac{54}{100}$	$\frac{67}{100}$	$\frac{84}{100}$	$1\frac{5}{100}$
Size of pipe..........	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside diam. of pipe	$1\frac{31}{100}$	$1\frac{66}{100}$	$1\frac{90}{100}$	$2\frac{37}{100}$	$2\frac{87}{100}$
Size of pipe..........	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside diam. of pipe	$3\frac{50}{100}$	$4\frac{00}{100}$	$4\frac{50}{100}$	$5\frac{00}{100}$	$5\frac{56}{100}$
Size of pipe..........	6	7	8	9	10
Outside diam. of pipe	$6\frac{62}{100}$	$7\frac{62}{100}$	$8\frac{62}{100}$	$9\frac{68}{100}$	$10\frac{77}{100}$

Size of Fresh Air Inlets to Indirect Stacks.

Where natural draught is depended upon for the movement of cold air to the indirect stacks of steam radiation, practice has found that for each square foot of radiation 1½ square inches of opening for cold air supply is necessary, or, in other words, for each 10 square feet of indirect radiation 15 square inches of cold air opening will answer.

The Amount of Direct Radiation that can be Heated by Exhaust Steam.

In calculating the heating capacity of an engine from its exhaust steam,there will be some difference in the make or style of such engine from which the exhaust steam is taken, and the better the engine the less will be the heating capacity per horse power of such engine from its exhaust steam; at the same time it will be a safe plan, based on practical experience, to allow from 100 to 125 feet of direct radiation per horse power of engine from which the exhaust steam is taken. Condensing engines, of course, not being considered for such purposes.

In exhaust steam heating plants where the feed water is heated by the exhaust steam, much of the heat from the exhaust steam will be extracted from the exhaust system by the feed water; and therefore this must be taken in consideration.

Size of Main Steam Pipes.

In calculating on the proper size of steam mains for gravity systems, lengths of such pipes as well as the square feet of surface in same must be considered. In situations where long runs of pipe are necessary between the boiler and radiating surface proper, one size larger pipe should be used for each 100 feet, and at the same time all mains figured as radiating surface when deciding on the sizes of such main pipe.

Radiating Surface Pipe will Supply.

Diameter of Pipe.	Area, Inches.	Radiation.	
		Direct.	Indirect.
1¼x1	1.49	150	85
1½x1¼	2.03	225	140
2 x1¼	3.35	350	200
2½x1½	4.78	500	300
3 x2	7.38	800	500
3½x2	9.83	1100	700
4 x2½	12.73	1500	1000
4½x2½	15.93	1800	1200
5 x3	19.99	2400	1600
6 x3½	28.88	3600	2200
7 x4	38.73	5000	3000
8 x4½	50.03	6500	4000
9 x5	63.63	8000	5400
10 x6	78.83	10000	7000

Number of threads to the inch of screw on American standard wrought iron, steam, gas and water pipe, from $\frac{1}{8}$ to 10 inches.

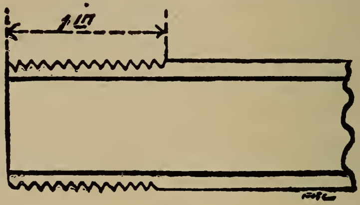


Fig. 9.

Size of pipe	⅛	¼	⅜	½	¾
Number of threads per inch	27	18	18	14	14
Size of pipe	1	1¼	1½	2	2½
Number of threads per inch	11½	11½	11½	11½	8
Size of pipe	3	3½	4	4½	5
Number of threads per inch	8	8	8	8	8
Size of pipe	6	7	8	9	10
Number of threads per inch	8	8	8	8	8

Safe plan of figuring steam heating, where hot water is used allow 25 % more radiation.

Glass Surface.

Allow 1 square foot of direct steam radiation, for each 3 square feet of glass.

Exposed Wall Surface.

Allow 1 square foot of direct steam radiation, for each 30 square feet of exposed wall.

Cubical Contents.

Allow 1 square foot of direct steam radiation for each 100 feet of space or contents of room.

Example.

If we have a room 13 feet wide, 15 feet long, and 10 feet high, as shown in Fig. 10, with one side and one end exposed to the exterior atmosphere, and having two windows, as shown, we proceed to find the necessary radiation as follows: We first find the cubical contents of the room, which is 1950 cubic feet. This we divide by 100, and result is 19½ square feet of radiation.

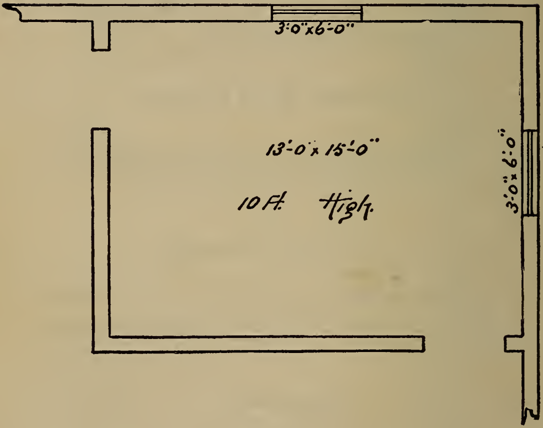


Fig. 10.

Next the exposed wall surface is taken, which is found to be 244 square feet, this exposed surface is divided by 30, and the result from this division is 8 square feet and a small fraction. The glass surface in the two windows is yet to be measured up, and as they are each 3x6 feet, the total amount of glass will be 36 square feet, and, as stated above, the glass surface is to be divided by 3; therefore $36 \div 3$ gives 12 square feet of radiation. We have now the three amounts of radiation, which, when added together equals $19\frac{1}{2}+8+12=39\frac{1}{2}$ square feet of direct steam radiation necessary to heat the room given in Fig. 10. This rule is intended for first floors, and for rooms above the first floor, from 10 to 20 % less radiation will answer.

This system equalizes each room to be warmed, giving it the proper proportion of radiation, not only according to its size, but exposure and amount of glass surface.

Outside doors must be figured the same as glass surface, and in measuring windows the entire width and height of sash should be taken. Even with the above system of getting the radiation there must be some judgment exercised in distributing the radiation, according to the points of compass. It is a good plan to add a little extra radiation for rooms situated on the north side of the house, and deduct it from rooms on the south side of the house.

Indirect Radiation.

To get the proper amount of indirect radiating surface for low pressure steam heating, 50% more surface is necessary than where direct surface is used, so that to warm the room, as shown in Fig. 10 by indirect radiation 60 square feet of radiation would be required.

Complete Soil and Waste Pipe System of a Modern Up-to-Date Residence.

Complete Soil and Waste Pipe System of a Modern Up-to-Date Residence.

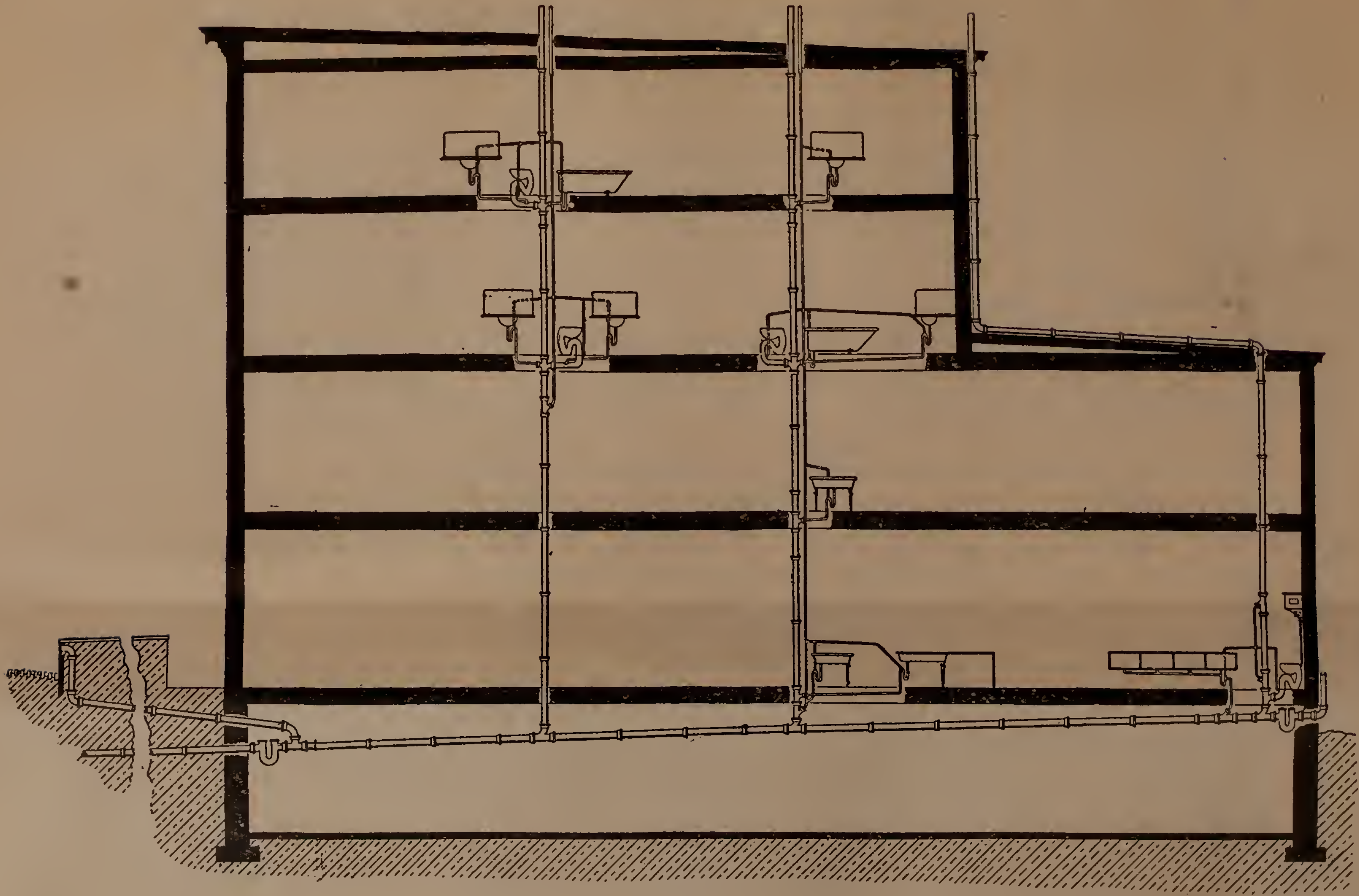


Fig. 11.

poi
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How Ends of Pipe Should be Reamed.

If the ordinary style of fittings are used on hot water circulating systems, such as are not recessed, all ends of pipes should be carefully reamed out in a manner as shown in illustration, Fig. 12, and unless the ends of pipes are reamed, taking off at least the burr, there will not only be a large amount of friction due to such obstructions, but the capacity of the pipe will be greatly reduced by the burrs contracting the area of the pipes at each end; and while the average fitter might consider this a small matter, and in a measure a waste of time to ream the ends of pipes, he is working against his own interests if he desires to construct a good, easy, and economical working heating plant. It more than pays, in fact it is a good investment to carefully construct the pipe work of a hot water heating plant, and avoid as much as possible any cause of friction to the movement of the water.

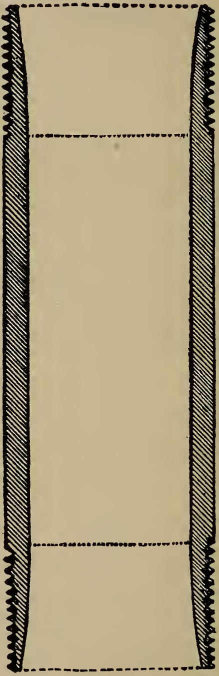

Fig. 12.

Under no consideration should lead be used in fittings as lead has a tendency to stop the circulation in time. A good practical man will always lead on the threads.

Rapid Circulation of Hot Water.

It must be remembered that the more rapid the circulation may be through the pipe system of a heating apparatus, the more heat will be given off through the radiating surface, and consequently the sluggish apparatus will require more radiating surface to do the same work of one having a good circulation, and this is where it will pay the heating engineer to use every effort in producing the best circulation possible. The quick circulating plant is also the most economical in the consumption of fuel, and therefore the consumer gets a better bargain, the better the circulation. All these points should be taken into consideration throughout the complete heating apparatus.

The style of radiation used must be considered not only as to its surface, but as to its construction regarding the circulation of water through it.

Some makes or styles of radiators may be good for steam heating, but might not answer at all for hot water heating, while on the other hand a good hot water radiator is always a good radiation for steam heating.

As stated in other parts of this book, the cause of circulation in hot water heating apparatus is the difference in weight of the water in the flow pipe and that in the return. And even with the greatest difference in temperature of these two columns of water that can be had in general house heating, the motive power will be very little, and consequently it is quite necessary to carry all hot water pipes in as favorable a manner as possible, avoiding all dips and air pockets, also short bends. A simple manner of illustrating friction in the flow of water through pipes at various angles is shown in the accompanying illustration, which represents five railway tracks. For a matter of comparison, let us suppose that a locomotive is placed on each track in a line, the tracks all being the same distance apart, but of different angles, and the locomotives all starting at the same time under the same conditions, it would not be necessary to ask the question which locomotive would reach the end of track first. By referring to the illustration the arrows indicate where situate close to the outside rail on the different tracks, the points of friction with which the outside wheels would have to contend. Track No. 1 is perfectly straight and therefore, has nothing to retard the motion of the wheel, as indicated by the arrows all in the center. Track 2 has a small curve which would very much retard the motion, while Tracks 3, 4 and 5 have still greater curves. By referring to Track 5, it will be noticed that in this case there will be friction from the very starting point to the finish, and this might represent an elbow in a hot water heating plant. Short Elbows and Bends, therefore, for such work are great obstacles to the rapid movement of water in any heating apparatus. Long Bends should be used where angles are necessary, in branches as well as elbows. It requires energy to produce friction, and energy is power; therefore, the energy and power used by friction in the pipes of a hot water heating apparatus require a certain percentage of the fuel consumed in the heater. This is a total loss, for the

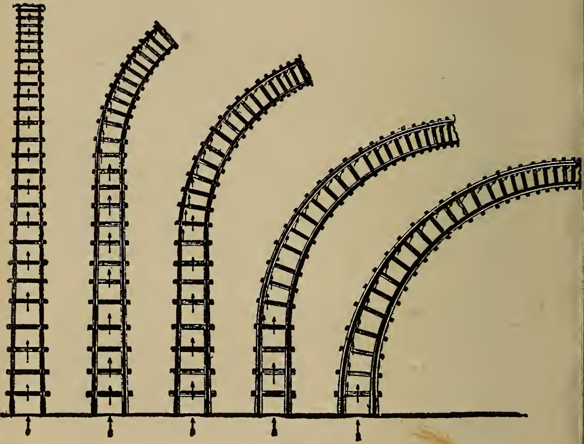

Fig. 13.

reason that from this percentage of fuel no heat is derived. Many fitters and plumbers are under the impression that whatever will conduct steam in a steam heating apparatus will also answer just as well for the conveying of hot water in a hot water heating apparatus, forgetting that steam and water are two widely different things. It must be remembered that when we have water flowing through a pipe we are dealing practically with a solid matter, compared to that of steam. There is practically no compressibility to water, and when in motion passing through pipes and bends, it produces friction to a much greater extent than steam or other gases, which have great flexibility. What do we gain with rapid circulation in a hot water heating apparatus? In the first place it is necessary to have the water circulate from the boiler to the radiators in order to convey the heat to the various rooms of the building. After the hot water has given off a portion of its heat to the radiators, its temperature will have lowered to a point where it is of no further use for imparting heat to the radiating surface. The particles of water after losing part of their heat, being no longer of value, must hurry back to the boiler, or source of heat, for a new supply, which in due course is again imparted to the radiating surface. Rapid circulation in a hot water heating apparatus benefits the boiler when considered from the standpoint of economy in fuel. Both the duty and action of the boiler in a heating plant are just the opposite to that of the radiation surface, and in order to get the most work from the boiler with the least amount of fuel, the return water must flow into the boiler as quickly as possible in order to take up as many as possible of the heat units produced by the fuel consumed in the boiler, and allow as little of heat to pass to the chimney unutilized. The more rapid the circulation of the water through the boiler the greater efficiency will be attained in the entire heating apparatus.

Water Capacity of a Boiler.

To find the water capacity of a horizontal tubular boiler of any size.

1. Multiply 2/3 of the area of the head in inches by the length of the boiler in inches.
2. Deduct the area of a single tube multiplied by the number in the boiler multiplied by the length in inches.
3. Divide by 231 to reduce the answer to gallons.

Example.

How much water (1/3 being steam space) will a boiler contain 6 feet in diameter and 18 feet long, with 100 3-inch tubes?

The area of 6 feet in inches=4071.5
And 2/3rds of this is 2714.3
Multiply by length 18 by inches×12= 216
————
162848
100 3-inch tubes to be deducted. 27143
No. Ft. In. 54286
Area 7×100×18×12
————
7×12=84 586288.8
8400×18= 15120.0
————
571168.8

231)571,1688
——————
24,726 gallons. Ans.

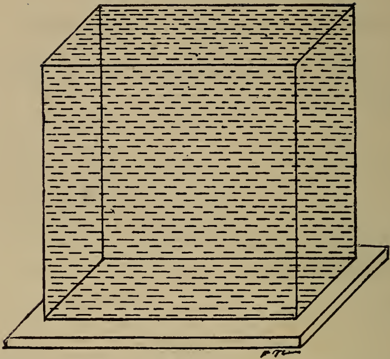

Fig. 14.

Table showing the pressure of water at different elevations.

Feet, Head.	Equals Pressure per Square Inch.	Feet, Head.	Equals Pressure per Square Inch.	Feet, Head.	Equals Pressure per Square Inch.	Feet, Head.	Equals Pressure per Square Inch.
1	0.34	100	43.31	195	84.47	290	125.62
5	2.16	105	45.48	200	86.63	295	127.78
10	4.38	110	47.64	205	88 80	300	129.97
15	6.49	115	49.81	210	90.96	310	134.28
20	8 66	120	51.98	215	93.14	320	138.62
25	10.82	125	54.15	220	95.30	330	142.94
30	12.99	130	56 31	225	97.49	340	147.28
35	15.16	135	58.48	230	99 63	350	151.61
40	17.32	140	60.54	235	101.79	360	155.94
45	19.49	145	62.81	240	103.96	370	160.27
50	21.65	150	64.97	245	106.13	380	164.61
55	23.82	155	67.14	250	108.29	390	168.94
60	25.99	160	69 31	255	110.46	400	173.27
65	28.15	165	71.47	260	112.62	500	216.58
70	30.32	170	73.64	265	114.79	600	259.90
75	32.48	175	75.80	270	116.96	700	303.22
80	34.65	180	77.97	275	119.12	800	346.54
85	36.82	185	80.14	280	121.29	900	389 86
90	38.98	190	82.30	285	123.45	1000	433.18
95	41.15	....	....	....	....	....	....

Trouble from Improper Turning of Steam Radiator Valves.

Still another source of trouble and loss of water from the boiler comes in the manner in which radiator valves are handled, especially on the two pipe system, and this is when it is desirable to close off the heat: The inlet valve is closed, while the return valve may be left partly or entirely open, thus allowing condensation to back up from some other source and thus storing up a considerable amount of water in the radiator, to the detriment of the boiler, because this water is not intended to accumulate in any part of the system above the return pipes, but fall by gravitation to the boiler. It will therefore be seen that on two pipe radiators, both valves must be left wide open or both perfectly closed, in order to have the apparatus operate in a proper manner. The same applies to a one pipe system as well.

Amount of Radiation Expansion Tank Will Carry.

Size, Inches.	Capacity, Gallons.	Sq. Ft. of Radiation	Size, Inches.	Capacity, Gallons.	Sq. Ft. of Radiation
10 x 20	8	250	16 x 36	32	1300
12 x 20	10	300	16 x 48	42	2000
12 x 30	15	500	18 x 60	66	3000
14 x 30	20	700	20 x 60	82	5000
16 x 30	26	950	22 x 60	100	6000

Illustration showing how to properly connect Expansion Tank.

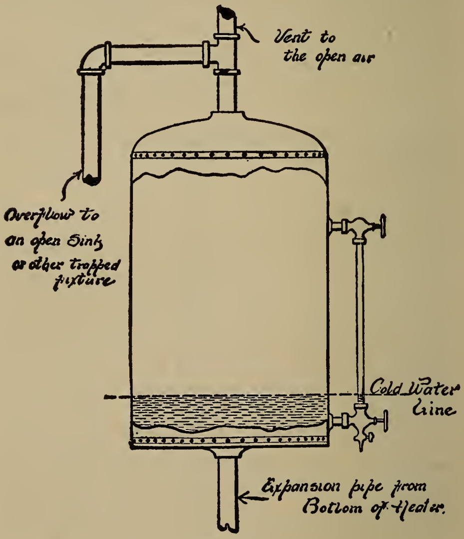

Fig. 15.

Every pound of coal requires a definite amount of air to burn it. It therefore requires ten times as much air to burn properly one hundred pounds of coal as it does to burn ten, and so on. Don't try to do what is impossible; a boy may sometimes be made to do a man's work, but a small chimney cannot possibly do the work of a large one.

Tank Capacity.

Diameter.				Gallons per Foot of Depth
2	Feet.		Inch	23.5
2	"	6	"	36.7
3	"			52.9
3	"	6	"	72.0
4	"			94.0
4	"	6	"	119.0
5	"			146.9
5	"	6	"	177.7
6	"			221.5
6	"	6	"	248.2
7	"			287.9
7	"	6	"	330.5
8	"			376.0
8	"	6	"	424.5
9	"			475.9
9	"	6	"	530.2
10	"			587.5
11	"			710.9
12	"			846.0
13	"			992.0
14	"			1151.5
15	"			1321.9
20	"			2350.1
25	"			3672.0
30	"			5287.7
35	"			7197.1
40	"			9400.3

Vertical and Horizontal Tank.

Capacity Gallons.	Diameter Inches.	Length Feet.	Approximate Weight.
66	18	5	220
85	20	5	250
100	22	5	280
120	24	5	320
145	24	6	360
170	24	7	400
180	30	5	480
215	30	6	540
250	30	7	590
300	30	8	640
325	36	6	780
365	36	7	810
420	36	8	880
430	42	6	1150
575	42	8	1400
720	42	10	1650

When a pipe coil or cast iron section is introduced into the firepot for the purpose of heating water for domestic use, additional capacity should be figured in determining size of Boiler, viz., in the case of Steam Boilers, 1¼ square feet of direct radiation for each gallon of water to be thus heated, and in the case of

Water Boilers, 2 square feet of direct radiation for each gallon of water to be thus heated, according to the capacity of the tank to which coil or section is connected.

When indirect radiation is to be used, not less than 75 per cent increase over direct radiation should be figured in determining the size of boiler required.

In rating steam boilers as above, it is understood that an average pressure of two pounds will be maintained at the Boiler. In rating water boilers as above, it is understood that the mean temperature of the water at the Boiler will be 180 degrees Fahrenheit.

Steam.

One-Pipe Work.

Radiators containing 24 square feet and under	1 inch
Above 24, but not exceeding 60 feet	1¼ inch
Above 60, but not exceeding 100 feet	1½ inch
Above 100 square feet	2 inch

Two-Pipe Work.

Radiators containing 48 square feet and under.	1 x ¾ inch
Above 48, but not exceeding 96 feet	1¼ x 1 inch
Above 96 square feet	1½ x 1¼ inch

Hot Water.

Tapped for Supply and Return.

Radiators containing 40 square feet and under	1 inch
Above 40, but not exceeding 72 square feet	1¼ inch
Above 72 square feet	1½ inch

Width, inches		Name of Radiator	Length occupied in Stack by each Section, Inches.
Legs	Intermediate Sections	Directs	
12½	12½	Aetna Flue	*3
5½	5⅛	Buffalo Single-Column	2½
8½	7¼	Buffalo Two-Column	2½
9⅛	8⅞	Buffalo Three-Column	2½
12	11⅝	Buffalo Four-Column	2½
8⅝	7¼	Excelsior	2
9¼	7¼	Favorite	2⅗
8½	7⅜	Ideal	*2½
8½	8½	Italian Flue	*3
5½	4½	National Single-Column	*2½
8½	7⅜	National Two-Column	*2½
11¼	10½	National Four-Column	*2¾
5½	4½	Peerless Single-Column	*2½
8½	7⅜	Peerless Two-Column	*2½
10¼	10	Peerless Three-Column	*2½
11¼	10½	Peerless Four-Column	*2¾
9¼	7¼	Perfection	*2½
10¼	10	Rococo Ornamental and Plain	*2½
6⅛	5½	St. Louis Single-Column	2½
8½	7	St. Louis Two-Column	2½
9⅛	9	St. Louis Three-Column	2½
12¾	11¾	St. Louis Four-Column	2½
11¾	11$\frac{5}{16}$	St. Louis Window	2½
8½	8	Verona	*2½
9½	8½	Zenith Flue	
6	5⅛	Zenith Narrow	
12¾	12½	Zenith Window	

*To length of these Radaitors add ½ inch for each bushing.

An Old, but Exceedingly Good Method of Lead Burning.

The apparatus required is a cast-iron furnace, two or three ladles, and some moulding sand. Burning is resorted to by plumbers generally for purposes where soldering will not stand.

Cast a sheet of lead of the proper thickness, and cut the proper length and width, turn it up round like a hoop, bringing the two ends well together to form a good joint on the outside, and firmly tack them together on the inside; roll it over to see that the joint is close on the outside, and paste a piece of stout brown paper about 4 inches wide over the whole length of the joint.

The sand must be well tempered, not to have any wet lumps in it; make a level bed with the sand about 5 or 6 inches thick; roll the hoop on the sand so that the joint will come under, be careful not to shift it backwards or forwards, but well ram up under both sides. Have a strip of wood rather longer than the joint, and $\frac{3}{4}$ inch thick, to form the runner with, place it along on edge on the top of the joint; now place some sand both sides and ram it well together, adding sand until there is a good bank on the top of the work; smooth it off with a trowel, cut it down towards the strip, so as to form a sort of funnel, leaving about 2 inches of the strip buried; draw out the strip endways, being careful not to break the sand, leaving one end stopped up, the other end stopped up about one inch high. At this end make a bay or pond for the overflow metal to run into. Have the metal red hot, be careful that the runner is free from loose sand, shake a little powdered rosin along the runner. Now begin to pour the metal, holding the ladle at least one foot above the runner so as to give weight and force to the burning metal; pour plenty, not minding what is running off, as the metal that is pouring in has to melt the part which is in the cold sand. When the joint is burned through try it by drawing the trying stick along in the runner; if it feels smooth along the bottom it is burned, if not, pour some more until it is, then stop up the end where the metal has been running off, and fill up about two inches high, and watch for shrinkage, having some hot metal ready to fill up as it shrinks down in cooling, or else the joint will not be round. When set, remove it from the sand, and cut off the runner with a mallet and chisel, finishing off with a piece of card wire, the paper on the outside will strip off, leaving it bright and clean.

Having now completed this part and set it up, round in shape, proceed with burning in the bottom; having a hole or pit in the floor, deep enough for the hoop to go down level with the floor, placing it in perfectly level. Fill up with the sand inside and out rather slackly. When filled up within four or five inches from the top, ram it down for the other part quite hard on the outside, leaving the sand rather higher than the edge; then with a straight-edge scrape off level with the edge of the lead.

Now with a scribe take out the sand the thickness of the required bottom, plane the sand off with a trowel, and the work will turn out clean. The sand on the outside being up level with the edge, smooth off, and cut a bay all around to take the overflow, shake a little rosin around the edge; having the metal red hot, begin to pour as before, only this is a work for two or three persons if it is any size, as it must be done quickly, pouring the metal along the edge until it is properly burned down; when it is burned deep enough, pour a few ladlefuls all over the bottom, so as to get in a thoroughly fluid state; then with the edge of the trowel clean off the dross, leaving a perfectly bright surface. Let it remain to set. This will not require any filling up, as it is open to the air and shrinks; when set it may be removed, and if well burned it will be perfectly solid.

Customary Plumbing for Various Buildings.

Dwelling Houses: The bathroom fixtures, laundry tubs and kitchen sink, with the addition of a slop sink, make up the usual fixtures to be provided for in the ordinary dwelling house. In houses of larger size these may be duplicated to some extent.

Apartment Houses: These are usually made up in duplicate flats, one above the other, so that the plumbing fixtures may be the same for each. It is customary to place the bath rooms in the same position on each floor so that a single soil pipe may care for all.

Hotels: Here, as in the case just described, the bath rooms are placed one above another, so that a single soil pipe may care for each series and the problem then becomes that of duplicating the lay-out for an apartment house. In addition to the private baths, there is a public lavatory or toilet room, usually on the first floor or in the basement. This is fitted up with closets, urinals and bowls. The Closet seats and urinals are placed side by side, with dividing partitions, and connect with a common soil pipe running back of them and having a good pitch. Each fixture should have its own trap. The flushing of the fixtures is often made automatic, so that pressing down the wooden rim of a closet seat will throw a lever, which on being released will flush the closet. Urinals are commonly made to flush at regular intervals. The lavatories are made up in long rows as a rule.

Railroad Stations: The plumbing of a railroad station is similar to that of a hotel, although even greater care should be taken to make the fixtures self-cleansing, as the patrons are likely to include many of the lowest and most ignorant class of people. Special attention should be given to both the local ventilation of the fixtures and the general ventilation of the room.

School Houses: The same general rules hold in the case of school buildings as in hotels and railroad stations. As the pupils are under the direct supervision of teachers and janitors, it is not necessary to have the fixtures automatic to as great an extent as in cases just described, and it is customary to flush the closets by means of tanks and pull chains or rods, the same as in private dwellings. The urinals may be automatic, or a small stream of water may be allowed to flow through them continuously during school hours.

Shops and Factories: Some simple type of fixture which may be easily cared for is best in buildings of this kind.

A few illustrations showing most successful methods of taking connections off mains and risers for hot water circulation, also showing branches connecting to radiators.

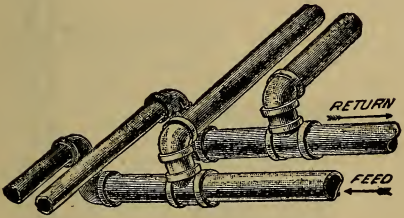

Fig. 16.

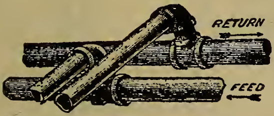

Fig. 17

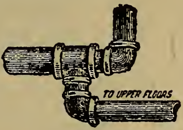

Fig. 18.

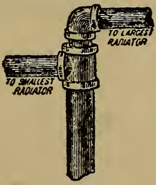

Fig. 19.

Illustrations showing best methods of making hot water radiator connections.

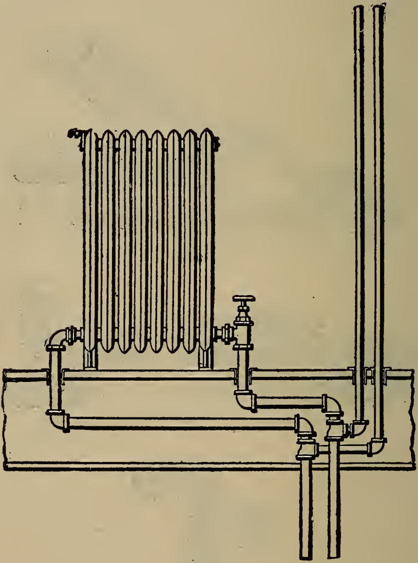

Fig. 20.

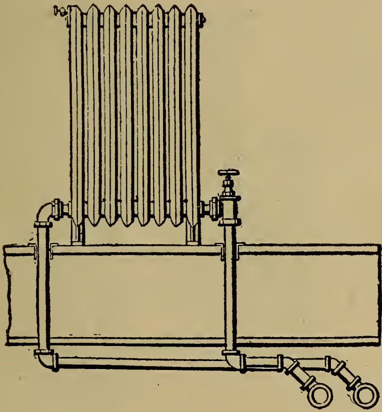

Fig. 21.

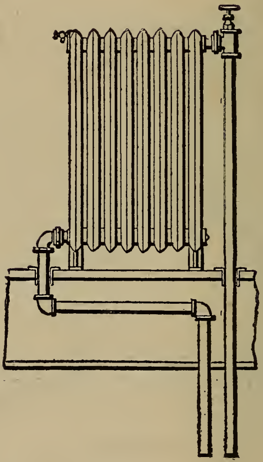

Fig. 22.

Illustrations showing proper methods of connecting radiators from overhead systems. Air valves are not needed in a system of this kind as shown in Figs. 23, 24.

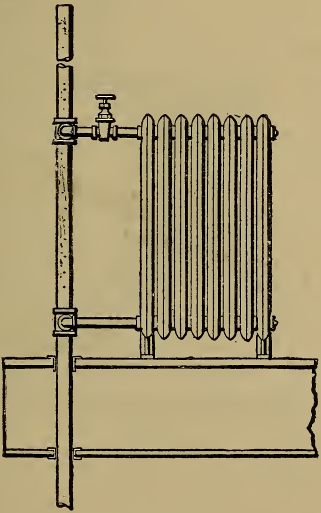

Fig. 23.

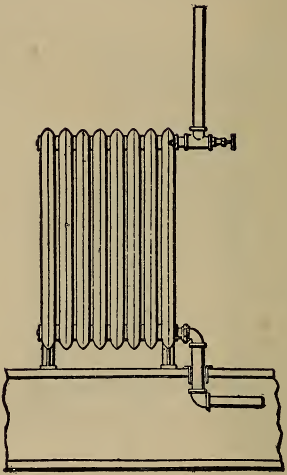

Fig. 24.

Weights and Measures.

MEASURE OF LENGTH.

4 In. make 1 Hand.
7.92 In. make 1 Link.
18 In. make 1 Cubit.
12 In. make 1 Foot.
6 Ft. make 1 Fathom.
3 Feet make 1 Yard.
5½ Yds. make 1 Rod or Pole.
40 Poles make 1 Furlong.
8 Fur. make 1 mile.
69 1-6 miles make 1 Degree.
60 Geographical Miles make 1 Degree.

$$\left.\begin{array}{l}\text{1760 Yards}\\ \text{5280 Feet}\end{array}\right\}\text{1 Mile.}$$

MEASURE OF SURFACE.

144 Square Inches make 1 Square Foot.
9 Square Feet make 1 Square Yard.
30¼ Square Yards make 1 Rod, Perch or Pole.
40 Square Rods make 1 Square Rood.
4 Square Roods make 1 Square Acre.
10 Square Chains make 1 Square Acre.
640 Square Acres make 1 Square Mile.
Gunter's Chain equal to 22 Yards or 100 Links.
272¼ Square Feet make 1 Square Rod.
43,560 Square Feet make 1 Acre.

MEASURE OF SOLIDITY.

1728 Cubic Inches make 1 Cubic Foot.
27 Cubic Feet make 1 Cubic Yard.

Useful Information.

A gallon of water (U. S. Standard) weighs 8 1-3 pounds, and contains 231 cubic inches.

A cubic foot of water weighs 62½ pounds, and contains 1,728 cubic inches, or 7½ gallons.

Each Nominal Horse-Power of boilers requires 1 cubic foot of water per hour.

In calculating horse-power of steam boilers, consider for tubular or flue boilers 15 square feet of heating surface equivalent to 1 horse power.

Condensing engines require from 20 to 25 gallons of water to condense the steam evaporated from one gallon of water.

To find the Pressure in Pounds Per Square Inch of a column of water, multiply the height of the column in feet by .434. (Approximately, every foot elevation is called equal to one-half pound per square inch.)

To find the Capacity of a Cylinder in Gallons. Multiplying the area in inches by the length of stroke in inches will give the total number of cubic inches; divide the amount by 231 (which is the cubical contents of a gallon in inches), and the product is the capacity in gallons.

Ordinary Speed to Run Pumps is 100 feet of piston per minute.

To find Quantity of Water elevated in one minute running at 100 feet of piston per minute. Square the diameter of water cylinder in inches and multiply by 4. Example: Capacity of a five inch cylinder is desired; the square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, which is gallons per minute, (approximately.)

To find the Diameter of a Pump Cylinder to move a given quantity of water per minute (100 feet of piston being the speed), divide the number of gallons by 4, then extract the square root, and the result will be the diameter in inches.

To find the Velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches.

To find the Area of a Required Pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144, and divide the product by the velocity in feet per minute. The area being found, it is easy to get the diameter of pipe necessary.

The Area of the Steam Piston multiplied by the steam pressure, gives the total amount of pressure exerted. The Area of the Water Piston, multiplied by the pressure of water per square inch, gives the resistance. A margin must be made between the power and the Resistance, to move the pistons at the required speed; usually reckoned at about 50 per cent.

Business Law in Daily Use.

The following compilation of business law contains the essence of a large amount of legal verbiage.

If a note is lost or stolen, it does not release the maker; he must pay it, if the consideration for which it was given and the amount can be proven.

Notes bear interest only when so stated.

Principals are responsible for the acts of their agents.

Each individual in a partnership is responsible for the whole amount of the debts of the firm, excepting in cases of special partnership.

Ignorance of the law excuses no one.

The law compels no one to do impossibilities.

An agreement without consideration is void.

A note made on Sunday is void.

Contracts made on Sunday cannot be enforced.

A note by a minor is void.

A contract made with a minor is void.

A contract made with a lunatic is void.

A note obtained by fraud, or from a person in a state of intoxication, cannot be collected.

It is a fraud to conceal a fraud.

Signatures made with a lead pencil are good in law.

A receipt for money is not always conclusive.

The acts of one partner bind all the rest.

"Value Received" is usually written in a note, and should be, but is not necessary. If not written it is presumed by the law, or may be supplied by proof.

The maker of an "accomodation" bill or note (one for which he has received no consideration, having lent his name or credit for the accommodation of the holder) is not bound to the person accommodated, but is bound to all other parties, precisely as if there was a good consideration.

No consideration is sufficient in law if it be illegal in its nature.

Checks or drafts must be presented for payment without unreasonable delay.

Checks or drafts should be presented during business hours, but in this country, except in the case of banks, the time extends through the day and evening.

If the drawee of a check or draft has changed his residence, the holder must use due or reasonable diligence to find him.

If one who holds a check as payee or otherwise, transfers it to another, he has a right to insist that the check be presented that day, or, at farthest, on the day following.

A note indorsed in blank (the name of the indorser only written), is transferable by delivery, the same as if made payable to bearer.

If the time of payment of a note is not inserted, it is held payable on demand.

Interest Table.

Four Per Cent.

TIME.	$1	$2	$3	$4	$5	$6	$7	$8	$9	$10	$100	$1000
1 Dy.	0	0	0	0	0	0	0	0	0	0	1	11
3 "	0	0	0	0	0	0	0	0	0	½	3½	33
5 "	0	0	0	0	0	0	0	½	½	½	5½	56
10 "	0	0	0	½	½	½	1	1	1	1	11	1 11
1 Mo.	0	½	1	1½	1½	2	2½	2½	3	3½	33	3 33
2 "	½	1½	2	2½	3½	4	4½	5½	6	6½	67	6 67
3 "	1	2	3	4	5	6	7	8	9	10	1 00	10 00
4 "	1½	2½	4	5½	6½	8	9½	10½	12	13½	1 33	13 33
6 "	2	4	6	8	10	12	14	16	18	20	2 00	20 00
9 "	3	6	9	12	15	18	21	24	27	30	3 00	30 00
1 Yr.	4	8	12	16	20	24	28	32	36	40	4 00	40 00

Five Per Cent.

TIME.	$1	$2	$3	$4	$5	$6	$7	$8	$9	$10	$100	$1000
1 Dy.	0	0	0	0	0	0	0	0	0	0	1	14
3 "	0	0	0	0	0	0	0	0	0	0	4	42
5 "	0	0	0	0	0	0	0	1	1	1	7	69
10 "	0	0	0	0	1	1	1	1	1	1½	14	1 39
1 Mo.	½	1	1	2	2	3	3	3	4	4	42	4 17
2 "	1	1½	3	3	4	5	6	7	8	8	83	8 33
3 "	1	2½	4	5	6	8	9	10	11	13	1 25	12 50
4 "	1½	3	5	7	8	10	12	13	15	17	1 67	16 67
6 "	2½	5	8	10	13	15	18	20	23	25	2 50	25 00
9 "	3¾	7½	11	15	19	23	26	30	34	38	3 75	37 50
1 Yr.	5	10	15	20	25	30	35	40	45	50	5 00	50 00

Six Per Cent.

TIME.	$1	$2	$3	$4	$5	$6	$7	$8	$9	$10	$100	$1000
1 Dy.	0	0	0	0	0	0	0	0	0	0	2	17
3 "	0	0	0	0	0	0	0	0	0	1	5	50
5 "	0	0	0	0	0	1	1	1	1	1	8	83
10 "	0	0	1	1	1	1	1	1	2	2	17	1 67
1 Mo.	½	1	2	2	3	3	4	4	5	5	50	5 00
2 "	1	2	3	4	5	6	7	8	9	10	1 00	10 00
3 "	1½	3	5	6	8	9	11	12	14	15	1 50	15 00
4 "	2	4	6	8	10	12	14	16	18	20	2 00	20 00
6 "	3	6	9	12	15	18	21	24	27	30	3 00	30 00
9 "	4½	9	14	18	23	27	32	36	41	45	4 50	45 00
1 Yr.	6	12	18	24	30	36	42	48	54	60	6 00	60 00

Amount of Air Used For a Blower System For Ventilation.

	Cubic feet per hour.
Hospitals	3,600 per Bed.
Legislative Assembly Halls	3,600 per Seat.
Barracks, Bedrooms and Workshops	3,000 per Person.
Schools and Churches	2,400 per Person.
Theaters and Ordinary Halls of Audience	2,000 per Seat.
Office Rooms	1,800 per Person.
Dining Rooms	1,800 per Person.

Rating of Tubular Boilers.

In figuring radiation, for every horse power allow 100 square feet of direct radiation.

Weight and Measurement of a Square Foot of Radiation.

A foot of prime radiation should weigh 6¾ pounds and hold one pint of water.

Tables of Mains and Branches for Hot Water.

1¼ in. will supply 2 .... 1 in.
1½ in. will supply 2 .... 1¼ in.
2 in. will supply 2 .... 1½ in.
2½ in. will supply 2 1½ in and 1 1¼ in., or 1 2 in. and 1 1¼ in.
3 in. will supply 1 2½ in. and 1 2 in., or 2 2 in. and 1 1½ in.
3½ in. will supply 2 2½ in. or 1 3 in., and 1 2 in. or 3 2 in.
4 in. will supply 1 3½ in. and 1 2½ in., or 2 3 in and 4 2 in.
4½ in. will supply 1 3½ in. and 1 3 in., or 1 4 in. and 1 2½ in.
5 in. will supply 1 4 in. and 1 3 in., or 1 4½ in. and 1 2½ in.
6 in. will supply 2 4 in. and 1 3 in., or 4 3 in. or 10 2 in.
7 in. will supply 1 6 in. and 1 4 in., or 3 4 in. and 1 2 in.
8 in. will supply 2 6 in. and 1 5 in., or 5 4 in. and 2 2 in.

Reaumur, 80°.	Centigrade, 100°.	Fahrenheit, 212°.	
76	95	203	Water Boils at Sea Level.
72	90	194	
68	85	185	
63.1	78.9	174	
60	75	167	Alcohol Boils
56	70	158	
52	65	149	
48	60	140	
44	55	131	
42.2	52.8	127	Tallow Melts.
40	50	122	
36	45	113	
33.8	42.2	108	
32	40	104	
29.3	36.7	98	Blood Heat.
28	35	95	
25.8	32.2	90	
24	30	86	
21.3	26.7	80	
20	25	77	
16	20	68	
12.4	15.3	60	Temperate.
10.2	12.8	55	
8	10	50	
5.8	7.2	45	
4	5	41	
1.3	1.7	35	
0	0	32	Water Freezes.
—0.9	—1.1	30	
—4	—5	23	
—5.3	—6.7	20	
—8	—10	14	
—9.8	—12.2	10	
—12	—15	5	
—14.2	—17.8	0	Zero Fahr.
—16	—20	—4	
—20	—25	—13	
—24	—30	—22	
—28	—35	—31	
—32	—40	—40	

The following formula gives the conversion of the above scales.

$F = R \times 9 \div 4 + 32°$ $F = C \times 9 \div 5 + 32°$

Useful Information.

PROPERTIES OF SATURATED STEAM

If steam is at 100 pounds by the gauge (115 lbs. absolute or total), its temperature is seen by the second column of the table to be 337.68° F., and a pound of it contains 1184.9 heat units above 32° F. This means that a pound of water at 32° F., if changed into steam at 100 lbs. pressure, will receive 1184.9 units of heat, of which 308.5 units were given to it while yet water as the temperature was raised from 32° to 337.66° F., as shown in column 4, and 876.5 units have become latent in the steam as the pound of water at 337.66° was changed into steam at 337.66°F. (see column 5). In column 6 it is seen that a cubic foot of steam at 100 lbs. pressure weighs only 0.2583 lbs., or about 4 ozs., or that 3.872 cubic foot (column 7) weigh a pound, although a cubic foot of water in the boiler at 337.66° F. weighs 56.18 lbs., as seen in column 8.

PIPE FACTORS.

Size of Pipe	For converting lineal feet to square feet	For converting sq. feet to lineal feet.	Size of Pipe	For converting lineal feet to square feet	For converting sq. feet to lineal feet
¾	.275	3.637	4½	1.309	.764
1	.334	2.994	5	1.590	.629
1¼	.434	2.30	6	1.733	.577
1½	.497	2.012	7	1.996	.501
2	.621	1.610	8	2.259	.443
2½	.752	1.330	9	2.544	.394
3	.916	1.090	10	2.817	.355
3½	1.047	.955	12	3.344	.299
4	1.179	.818			

Multiply quantities by constants shown in respective columns

EQUATION OF PIPES.

1¼	1½	2	2½	3	3½	4	4½	5	6	7	8
.126	1.44	1.81	2 19	2.66	3 04	3.42	3.80	4.23	5.03	5.80	6.55

To compute the equivalent in 1-inch pipe of a given quantity of pipe of other sizes, multiply the number of lineal feet of a certain size of pipe by the figure underneath that size in the above table.

For example:—5,000 feet of 1¼-inch pipe, 4,000 feet 2½-inch and 2,000 feet 3-inch is equivalent to 20,380 feet of 1-inch pipe, being the sum total found by multiplying 5,000x1.26, 4,000x2.19, and 2,000 x 2.66.

Horse Power of an Engine.

a equals Area of piston in square inches.
p equals Mean pressure of the steam on the piston per square inch.
v equals Velocity of piston per minute in feet.

$$\text{Then H. P. equals } \frac{a \times p \times v}{33000}$$

The mean pressure in the cylinder when cutting off at

¼ Stroke equal boiler pressure × .597
⅓ Stroke equal boiler pressure × .670
⅜ Stroke equal boiler pressure × .743
½ Stroke equal boiler pressure × .847
⅝ Stroke equal boiler pressure × .919
⅔ Stroke equal boiler pressure × .937
¾ Stroke equal boiler pressure × .966
⅞ Stroke equal boiler pressure × .992

To find the weight of the rim of the fly wheel for an engine:

$$\frac{\text{Nominal H. P.} \times 2000}{\text{The square of the velocity of the circumference in feet per second.}} \text{ equals weight in cwts.}$$

RELATIVE VALUE OF HEATING SURFACE.

Horizontal surfaces above the flame equal.....1.00
Vertical surfaces above the flame equal....... .50
Horizontal surfaces beneath the flame......... .10
Tubes and Flues equal 1¼ times their diameter.
Convex surfaces above the flame equal 1 1-6 diam.

FEED WATER REQUIRED BY SMALL ENGINES.

Gauge Pressure at Boiler	Lbs. Water per Effective H. P. per Hour.	Gauge Pressure at Boiler.	Lbs Water per Effective H. P. per Hour.
10	118	60	75
15	111	70	71
20	105	80	68
25	100	90	65
30	93	100	63
40	81	120	61
50	79	150	58

Elbows.

Size.
¼x ¼
⅜x ⅜
½x ½
½x ⅜
¾x ¾
¾x ½

1 x1
1 x ¾
1 x ½

1¼x1¼
1¼x1
1¼x ¾
1¼x ½

1½x1½
1½x1¼
1½x1
1½x ¾

Size.
2 x2
2 x1½
2 x1¼
2 x1

2½x2½
2½x2
2½x1½

3 x3
3 x2½
3 x2

3½x3½
3½x3

4 x4
4 x3½
4 x3
4 x2½

Size.
4½x 4½
4½x 4

5 x 5
5 x 4

6 x 6
6 x 5
6 x 4

7 x 7

8 x 8
8 x 6

9 x 9

10 x10

12 x12

45° Elbows.

Size, inches....⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 9, 10, 12, 14.

Pitched Elbows.

Size, inches....1x¾, 1, 1¼x1, 1¼, 1½x1¼, 1½, 2x1½, 2, 2½x2, 2½, 3.

Right and Left Elbows.

Size, inches....¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3.

Tees.

In describing Tees, the run is first named, then the outlet, thus:

½ T ⅜=½x⅜x¾
¾

Size.

¼x ¼x ¼
⅜x ⅜x ½
⅜x ⅜x ⅜

½x ½x1
½x ½x ¾
½x ½x ½
½x ½x ⅜
½x ⅜x ½
½x ⅜x ⅜

¾x ¾x2
¾x ¾x1½
¾x ¾x1¼
¾x ¾x1
¾x ¾x ¾
¾x ¾x ½
¾x ¾x ⅜
¾x ½x1
¾x ½x ¾
¾x ½x ½
¾x ⅜x ¾
¾x ⅜x ⅜

1 x1 x2
1 x1 x1½
1 x1 x1¼
1 x1 x1
1 x1 x ¾
1 x1 x ½
1 x1 x ⅜
1 x ¾x2
1 x ¾x1½

Size.

1 x ¾x1¼
1 x ¾x1
1 x ¾x ¾
1 x ¾x ½
1 x ½x1
1 x ½x ¾
1 x ½x ½
1 x ⅜x1

1¼x1¼x2
1¼x1¼x1½
1¼x1¼x1¼
1¼x1¼x1
1¼x1¼x ¾
1¼x1¼x ½
1¼x1 x2
1¼x1 x1½
1¼x1 x1¼
1¼x1 x1
1¼x1 x ¾
1¼x1 x ½
1¼x ¾x2
1¼x ¾x1½
1¼x ¾x1¼
1¼x ¾x1
1¼x ¾x ¾
1¼x ½x1½
1¼x ½x1¼

1½x1½x2½
1½x1½x2
1½x1½x1½
1½x1½x1¼

Size.

1½x1½x1
1½x1½x ¾
1½x1½x1½
1½x1¼x2
1½x1¼x1½
1½x1¼x1¼
1½x1¼x1
1½x1¼x ¾
1½x1¼x ½
1½x1 x2
1½x1 x1½
1½x1 x1¼
1½x1 x1
1½x1 x ¾
1½x1 x ½
1½x ¾x2
1½x ¾x1½
1½x ¾x1¼
1½x ¾x1
1½x ¾x ¾
1½x ½x1½
1½x ½x1¼

2 x2 x3
2 x2 x2½
2 x2 x2
2 x2 x1½
2 x2 x1¼
2 x2 x1
2 x2 x ¾
2 x2 x ½
2 x1½x2½

Tees—Continued.

Size.
4 x2½x4
4 x2½x3
4 x2½x2½
4 x2½x2
4 x2½x1½
4 x2½x1
4 x2 x4
4 x2 x3
4 x2 x2½
4 x2 x2
4 x2 x1½
4 x1½x4
4 x1¼x4
4 x1 x4

4½x4½x4½
4½x4½x4
4½x4½x3½
4½x4½x3
4½x4½x2½
4½x4½x2
4½x4½x1½

5 x5 x6
5 x5 x5
5 x5 x4½
5 x5 x4
5 x5 x3½
5 x5 x3
5 x5 x2½
5 x5 x2
5 x5 x1½
5 x5 x1¼
5 x4 x5
5 x4 x4½
5 x4 x4
5 x4 x3
5 x4 x2
5 x4 x2
5 x3 x5

Size.
5 x3 x4½
5 x3 x4
5 x3 x3½
5 x3 x3
5 x3 x2½
5 x3 x2
5 x2½x5
5 x2½x4
5 x2½x3
5 x2 x5

6 x6 x8
6 x6 x7
6 x6 x6
6 x6 x5
6 x6 x4½
6 x6 x4
6 x6 x3½
6 x6 x3
6 x6 x2½
6 x6 x2
6 x5 x6
6 x5 x5
6 x4 x6
6 x3 x6
6 x2½x6

7 x7 x7
7 x7 x6
7 x7 x5
7 x7 x4
7 x7 x3½
7 x7 x3
7 x7 x2½
7 x6 x7
7 x6 x6
7 x6 x5
7 x5 x6
7 x5 x5

Size.
8x 8x 8
8x 8x 7
8x 8x 6
8x 8x 5
8x 8x 4½
8x 8x 4
8x 8x 3½
8x 8x 3
8x 8x 2½
8x 8x 2
8x 7x 8
8x 7x 6
8x 6x 8
8x 6x 7
8x 6x 6
8x 5x 8
8x 4x 8
8x 5x 5

9x 9x 9
9x 9x 5

10x10x10
10x10x 8
10x10x 6
10x10x 5
10x10x 4
10x 8x 8

12x12x12
12x12x10
12x12x 8
12x12x 6
12x12x 4
12x 8x10
12x 8x 8

14x14x14
14x14x 8
14x14x 6

Tees—Continued.

Size.

2 x1½x2
2 x1½x1½
2 x1½x1¼
2 x1½x1
2 x1½x ¾
2 x1½x ½
2 x1¼x2
2 x1¼x1½
2 x1¼x1¼
2 x1¼x1
2 x1¼x ¾
2 x1 x2
2 x1 x1½
2 x1 x1¼
2 x1 x1
2 x1 x ¾
2 x ¾x2
2 x ¾x1½
2 x ½x2

2½x2½x4
2½x2½x3
2½x2½x2½
2½x2½x2
2½x2½x1½
2½x2½x1¼
2½x2½x1
2½x2½x ¾
2½x2½x ½
2½x2 x3
2½x2 x2½
2½x2 x2
2½x2 x1½
2½x2 x1¼
2½x2 x1
2½x1½x2½
2½x1½x2
2½x1½x1½
2½x1½x1¼

Size.

2½x1½x1
2½x1¼x2½
2½x1¼x2
2½x1 x2½
2½x ¾x2½

3 x3 x4
3 x3 x3½
3 x3 x3
3 x3 x2½
3 x3 x2
3 x3 x1½
3 x3 x1¼
3 x3 x1
3 x3 x ¾
3 x2½x3
3 x2½x2½
3 x2½x2
3 x2½x1½
3 x2½x1¼
3 x2½x1
3 x2 x3
3 x2 x2½
3 x2 x2
3 x2 x1½
3 x2 x1¼
3 x2 x1
3 x1½x3
3 x1½x2½
3 x1½x2
3 x1¼x3
3 x1 x3

3½x3½x4
3½x3½x3½
3½x3½x3
3½x3½x2½
3½x3½x2

Size.

3½x3½x1½
3½x3½x1¼
3½x3½x1
3½x3 x3
3½x3 x2½
3½x3 x2
3½x3 x1½
3½x2½x3
3½x2½x2½
3½x2½x2
3½x2 x3½
3½x1½x3½
3½x1¼x3½
3½x1 x3½

4 x4 x6
4 x4 x5
4 x4 x4
4 x4 x3½
4 x4 x3
4 x4 x2½
4 x4 x2
4 x4 x1½
4 x4 x1¼
4 x4 x1
4 x4 x ¾
4 x3½x4
4 x3½x3½
4 x3½x3
4 x3½x2½
4 x3 x4
4 x3 x3½
4 x3 x3
4 x3 x2½
4 x3 x2
4 x3 x1½
4 x3 x1¼
4 x3 x1
4 x3 x ¾

Bushings.

Size.

⅜x ⅛ Brass
¼x ⅛ Brass
⅜x ¼
½x ¼
½x ⅜

¾x ¼
¾x ⅜
¾x ½

1 x ¼
1 x ⅜
1 x ½
1 x ¾

1¼x ¼
1¼x ⅜
1¼x ½
1¼x ¾
1¼x1

1½x ½
1½x ¾
1½x1
1½x1¼

2 x ½
2 x ¾
2 x1
2 x1¼
2 x1½

2½x ¾
2½x1
2½x1¼

Size.

2½x1½
2½x2

3 x1
3 x1¼
3 x1½
3 x2
3 x2½

3½x1
3½x1¼
3½x1½
3½x2
3½x2½
3½x3

4 x1
4 x1¼
4 x1½
4 x2
4 x2½
4 x3
4 x3½

4½x2½
4½x3
4½x3½
4½x4

5 x2
5 x2½
5 x3
5 x3½
5 x4
5 x4½

Size.

6x 2
6x 2½
6x 3
6x 3½
6x 4
6x 4½
6x 5

7x 2
7x 2½
7x 3
7x 3½
7x 4
7x 4½
7x 5
7x 6

8x 3
8x 4
8x 5
8x 6
8x 7

9x 6
9x 7
9x 8

10x 6
10x 8

12x 6
12x 8
12x10

Crosses.

Size.

½x ½x ½x ½
½x ½x ⅜x ⅜
½x ½x ¼x ¼

¾x ¾x ¾x ¾
¾x ¾x ½x ½
¾x ¾x ⅜x ⅜

1 x1 x1 x1
1 x1 x ¾x ¾
1 x1 x ½x ½

1¼x1¼x1¼x1¼
1¼x1¼x1 x1
1¼x1¼x ¾x ¾
1¼x1¼x ½x ½

1½x1½x1½x1½
1½x1½x1¼x1¼
1½x1½x1 x1
1½x1½x ¾x ¾
1½x1½x ½x ½
1½x1¼x1 x1

2 x2 x2 x2
2 x2 x1½x1½
2 x2 x1¼x1¼
2 x2 x1 x1
2 x2 x ¾x ¾

Size.

2½x2½x2½x2½
2½x2½x2 x2
2½x2½x1½x1½
2½x2½x1¼x1¼
2½x2½x1 x1
2½x2½x ¾x ¾
2½x2 x1½x1½

3 x3 x3 x3
3 x3 x2½x2½
3 x3 x2 x2
3 x3 x1½x1½
3 x3 x1¼x1¼
3 x3 x1 x1
3 x3 x ¾x ¾

3½x3½x3½x3½
3½x3½x3 x3
3½x3½x2½x2½
3½x3½x2 x2

4 x4 x4 x4
4 x4 x3½x3½
4 x4 x3 x3
4 x4 x2½x2½
4 x4 x2 x2

4½x4½x4½x4½

Size.

5x 5x 5 x 5
5x 5x 4 x 4
5x 5x 3 x 3
5x 5x 2½x 2½
5x 5x 2 x 2

6x 6x 6 x 6
6x 6x 5 x 5
6x 6x 4 x 4
6x 6x 3½x 3½
6x 6x 3 x 3
6x 6x 2½x 2½
6x 6x 2 x 2

7x 7x 7 x 7
7x 7x 6 x 6
7x 7x 5 x 5
8x 8x 8 x 8
8x 8x 7 x 7
8x 8x 6 x 6
9x 9x 9 x 9
10x10x10 x10
10x10x 8 x 8
10x10x 7 x 7
12x12x12 x12
12x12x10 x10
12x12x 8 x 8

Horizontal Fire-Box Boilers for Steam Heating.

Number		1	2	3	4	5	6	7	8	9	10	11	12
Length	Inches.	78	90	102	90	108	126	102	120	138	126	144	162
Diameter of Shell	"	80	30	30	36	36	36	42	42	42	48	48	48
Tubes, Number		40	40	40	40	40	40	52	52	52	48	48	48
Tubes, Length	Inches.	49	55	61	55	67	79	61	73	85	79	91	103
Tubes, Diameter	"	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3
Fire-box, Length	"	26	32	38	32	38	44	38	44	50	44	50	56
Fire-box, Width	"	24	24	24	30	30	30	36	36	36	42	42	42
Fire-box, Height	"	31	31	31	36	36	36	41	41	41	45	45	45
Thickness of Shell	"	¼	¼	¼	¼	¼	¼	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$
" " Heads	"	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	⅜	⅜	⅜	⅜	⅜	⅜
" " Fire-box	"	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	⅜	⅜	⅜
Depth of Water Leg	"	10	10	10	11	11	11	12	12	12	12	12	12
Approx. Weight, (exclusive of Grates and Castings)	in Lbs.	1762	1946	2151	2510	2860	3207	3709	4186	4663	4970	5611	6234

Heating Surfaces and Grate Areas.

Heating Surfaces, Firebox		25	28	32	37	41	45	50	56	61	65	71	76
Heating Surfaces, Tubes		101	114	126	138	168	197	198	236	275	290	335	379
Heating Surfaces, Shell		26	30	36	36	43	50	47	55	63	66	76	86
Total Heating Surface	Square Feet	152	172	194	211	252	292	295	347	399	421	482	541
Grate Area	" "	4.3	5.3	6.3	6.7	8.0	9.2	9.5	11.	12.5	13.	14.7	16.4

Horizontal Fire-Box Boilers for Hot Water Heating.

Number		1	2	3	4	5	6	7	8
Length	Inches.	90	95	99	108	108	114	120	126
Diameter of Shell	"	27	30	33	36	39	42	45	48
Tubes, Number		38	49	42	49	60	66	64	66
Tubes, Length	Inches.	52	52	55	55	58	61	64	67
Tubes, Diameter	"	2	2	2½	2½	2½	2½	3	3
Fire-box, Length	"	35	38	41	44	47	50	53	56
Fire-box, Width	"	21	24	27	30	33	36	39	42
Fire-box, Height	"	33	37	39	41	44	46	48	50
Thickness of Shell	"	¼	¼	¼	¼	¼	¼	5/16	5/16
" " Heads	"	5/16	5/16	5/16	5/16	⅜	⅜	⅜	⅜
" " Fire Box	"	¼	5/16	5/16	5/16	5/16	⅜	⅜	⅜
Depth of Water Leg	"	10	10	11	11	12	12	12	12
Approx. Weight, (exclusive of Grates and Castings)	in Lbs.	1862	2224	2579	2918	3629	4007	5048	5472

Heating Surfaces and Grate Areas.

		1	2	3	4	5	6	7	8
Heating Surfaces, Shell		26	30	36	42	46	52	60	66
Heating Surfaces, Tubes		102	131	144	186	218	253	314	367
Heating Surfaces, Firebox		31	38	45	51	59	67	79	84
Total Heating Surface	Square Feet.	159	199	225	279	323	372	453	517
Grate Area	" "	5.1	6.3	7.6	9.2	10.7	12.5	14.3	16.4

RELATIVE CAPACITIES OF PIPES

For Conveying or Discharging Liquids and Gases.

Diams.	¾	1	1¼	1½	2	2½	3	3½	4	5	6	7	8	9	10	11	12	14	Diams.
¾	1	2.05	3.57	5.66	11.61	20.40	31.98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	¾
1	...	1.00	1.74	2.75	5.66	9.87	15.57	23.00	32.00	56.00	88.00	129.00	181.00	243.00	316.00	401.00	498.00	733.00	1
1¼	...	....	1.00	1.57	3.21	5.66	8.95	13.21	18.39	32.12	50.67	74.10	104.00	139.00	181.00	230.00	286.00	478.00	1¼
1½	...	....	....	1.00	2.05	3.57	5.66	8.39	11.61	20.28	32.18	47.04	66.00	88.00	115.00	146.00	182.00	267.00	1½
2	...	....	....	....	1.00	1.74	2.75	4.06	5.66	9.87	15.57	22.90	31.98	42.93	55.86	70.90	88.13	129.50	2
2½	...	....	..	....	....	1.00	1.57	2.32	3.21	5.66	8.93	13.13	18.33	24.61	32.02	40.64	50.52	74.27	2½
3	..	....	....	....	.....	.....	1.00	1.47	2.05	3.57	5.66	8.39	11.61	15.57	20.28	25.74	32.18	47.04	3
3½	...	....	....	....	.....	.....	....	1.00	1.39	2.43	3.83	5.66	7.91	10.57	14.10	17.45	21.69	31.89	3½
4	...	..	..	....	.....	.....	.....	.....	1.00	1.74	2.75	4.06	5.66	7.59	9.87	12.54	15.57	22.90	4
5	...	...	....	....	.....	.....	.....	.....	.....	1.00	1.57	2.32	3.24	4.24	5.66	7.17	8.93	13.13	5
6	...	....	...	....	.....	.....	.....	.....	.....	.....	1.00	1.47	2.05	2.75	3.57	4.55	5.66	8.39	6
7	...	..	....	....	.....	.....	.....	.....	.....	.....	.....	1.00	1.39	1.88	2.43	3.09	3.83	5.66	7
8	...	....	....	....	.....	.....	.....	.....	.....	.....	.....	......	1.00	1.33	1.74	2.21	2.75	4.06	8
9	...	....	...	....	.....	.....	.....	.....	.....	.....	.....	......	......	1.00	1.20	1.65	2.05	3.01	9
10	...	....	...	....	.....	.....	.....	.....	.....	.....	.....	......	......	......	1.00	1.26	1.57	2.32	10
11	...	....	....	....	.....	.....	.....	.....	.....	.....	....	......	......	......	......	1.00	1.24	1.80	11
12	...	....	....	....	.....	.....	....	.....	.....	.....	.....	......	......	......	.....	......	1.00	1.47	12
14	...	....	....	....	.....	.....	.....	.....	.....	.....	.....	......	......	......	......	......	......	1.00	14

The capacity of a pipe is in inverse proportion to the square root of its length.
Doubling the diameter of a pipe increases its capacity 5.66 times.

Diameter of Flanges and Templates for Drilling.

Size, Inches.	Diameter of Flanges, Inches.	Diameter of Bolt Circle, Inches.	Number of Bolts.	Size of Bolts.
2	6	4¾	4	⅝
2½	7	5½	4	⅝
3	7½	6	4	⅝
3½	8½	6¾	4	⅝
4	9	7¼	8	⅝
4½	9¼	7¾	8	⅝
5	10	8¼	8	⅝
6	11	9¼	8	⅝
7	12½	11	12	⅝
8	13½	12	12	⅝
9	15	13	12	¾
10	16	14¼	12	¾
12	19	17	16	¾
14	21	18½	16	⅞
16	23½	21½	20	⅞
18	25	22½	20	⅞
20	27½	24¾	20	1
22	29½	27½	24	1
24	31½	29½	24	1
30	38	36	32	1⅛

Air and Water Pressure Tanks.

Diameter, Feet.	Length, Feet.	THICKNESS		Weight	Capacity, Gallons
		Shell.	Heads.		
5	20	5/16	3/8	6250	2922
5	25	5/16	3/8	7390	3654
5	30	5/16	3/8	8580	4384
6	20	5/16	1/2	7800	4240
6	28	5/16	1/2	10200	5936
6	36	5/16	1/2	12450	7632
7	20	5/16	1/2	8600	5761
7	28	5/16	1/2	11100	8066
7	36	5/16	1/2	13600	10370
8	24	5/16	1/2	11800	8980
8	30	5/16	1/2	14000	11224
8	36	5/16	1/2	16200	13468

Air and Water Pressure Tanks.

Diameter, Inches.	Length, Feet	Weight	Capacity, Gallons
24	6	350	140
24	8	420	190
24	10	500	235
30	6	530	220
30	8	650	295
30	10	770	365
30	12	900	440
30	14	1000	515
36	6	750	315
36	8	900	420
36	10	1050	525
36	12	1200	630
36	14	1400	735
36	16	1575	840
42	8	1450	575
42	10	1650	720
42	12	1900	865
42	14	2200	1000
42	16	2400	1150
42	18	2650	1300
42	20	2900	1440
48	10	2200	940
48	12	2550	1130
48	14	2900	1300
48	16	3250	1500
48	18	3600	1700
48	20	3950	1880
48	24	4650	2260

Circumference of Circles.

Comprehensible Meters Used by Boilermakers.

Diameter in Inches.	Circumference in Inches.	Diameter in Inches.	Circumference in Inches.
12	37⅝	48	150¾
14	44	50	157
16	50⅛	52	163¼
18	56½	54	169⅝
20	62¾	56	175⅞
22	69	58	182⅛
24	75⅜	60	188⅛
26	81⅝	62	194¾
28	87⅞	64	201
30	94¼	66	207¼
32	100½	68	213⅝
34	106¾	70	219⅞
36	113	72	226⅛
38	119⅜	74	232⅜
40	125⅝	76	238⅝
42	131⅞	78	244⅞
44	138⅛	80	251½
46	141½	82	257½

Boilermakers usually add three times the thickness of the plate to the length of iron for the takeup in rolling; also add for laps, single or double riveting.

Weights of Iron and Steel Plates.

Weight Per Square Foot.

Thickness in Inches.	Iron.	Steel.	Thickness in Inches.	Iron.	Steel.
⅛	5.052	5.31	½	20.21	21.
3/16	7.578	8.00	9/16	22.73	23.62
¼	10.10	10.62	⅝	25.26	26.25
9/32	11.37	11.83	11/16	27.79	28.87
5/16	12.62	13.12	¾	30.31	31.50
⅜	15.16	15.75	⅞	35.37	36.75
7/16	17.68	18.37	1	40.42	42.

Liberal allowance must be made for these weights on wide plates.

Number of U. S. Gallons in Rectangular Tanks.

FOR ONE FOOT IN DEPTH.

Width of Tank	LENGTH OF TANK.																				
	2 ft.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft.	5 ft. 6 in.	6 ft.	6 ft. 6 in.	7 ft.	7 ft. 6 in.	8 ft.	8 ft. 6 in.	9 ft.	9 ft. 6 in.	10 ft.	10 ft. 6 in.	11 ft.	11 ft. 6 in.	12 ft.
2 ft	30	37	45	52	60	67	75	82	90	97	105	112	120	127	135	142	150	157	165	172	180
2 ft. 6 in	....	47	56	65	75	84	94	103	112	122	131	140	150	159	168	178	187	196	206	215	224
3 ft	....	....	67	79	90	101	112	123	135	146	157	168	180	191	203	213	224	236	247	258	269
3 ft. 6 in	....	....	....	92	105	118	131	144	157	170	183	196	209	223	236	249	262	275	288	301	314
4 ft	....	....	....	....	120	135	150	165	180	194	209	224	239	254	269	284	299	314	329	344	359
4 ft. 6 in	....	....	....	....	....	151	168	185	202	219	236	252	269	286	303	320	337	353	370	387	404
5 ft	....	....	....	....	....	....	187	206	224	243	262	281	299	318	337	355	374	393	411	430	449
5 ft. 6 in	....	....	....	....	....	....	....	226	247	267	288	309	329	350	370	391	411	432	453	473	494
6 ft	....	....	....	....	....	....	....	....	269	292	314	337	359	381	404	426	449	471	494	516	539
6 ft. 6 in	....	....	....	....	....	....	....	....	....	316	340	365	389	413	438	462	486	511	535	559	583
7 ft	....	....	....	....	....	....	....	....	....	....	367	393	419	445	471	497	524	550	576	602	628
7 ft. 6 in	....	....	....	....	....	....	....	....	....	....	....	421	449	477	505	533	561	589	617	645	673
8 ft	....	....	....	....	....	....	....	....	....	....	....	....	479	509	540	569	598	628	658	688	718
8 ft. 6 in	....	....	....		....	....	....	....	....	....	....	....	....	540	572	604	636	668	699	731	763
9 ft	....	....	....	....	....	....	....	....	....	....	....	....	....	....	606	640	673	707	741	774	808
9 ft. 6 in	....	....	....	....	....	....	....	....	....	....	....	....	..	....	..	675	711	746	782	817	853
10 ft	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	748	785	823	860	898
10 ft. 6 in	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	825	864	903	943
11 ft	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	905	946	987
11 ft. 6 in	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	989	1032
12 ft	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1077

GAS FITTERS' RULES

Office Buildings
Dwelling Houses
and Flats

MANUFACTURED GAS FOR LIGHT

The following tables show the proportionate size and length of tubing allowed.

Size of Tubing.	Greatest Length Allowed.	Greatest Number of ⅜ in. Openings Allowed.
⅜ inch	20 feet	2 openings
½ inch	30 feet	3 openings
¾ inch	60 feet	10 openings
1 inch	70 feet	15 openings
1¼ inch	100 feet	30 openings
1½ inch	150 feet	60 openings
2 inch	200 feet	100 openings
2½ inch	200 feet	000 openings
3 inch	300 feet	000 openings

Drops in double parlors, large rooms and halls of office buildings must not be less than ½ inch.

Stores, Hospitals, Schools, Factories, Etc.

MANUFACTURED GAS FOR LIGHT

Size of Tubing.	Greatest Length Allowed.	Greatest Number of ½ in. Openings Allowed.
½ inch	20 feet	1 opening
¾ inch	60 feet	8 openings
1 inch	70 feet	12 openings
1¼ inch	100 feet	20 openings
1½ inch	150 feet	35 openings
2 inch	200 feet	50 openings

For stores the running line to be full size to the end of last opening.

All drops to be ½ inch, with set not less than 4 inches.

20 feet of ⅜-inch pipe allowed only for bracket lights.

BUILDING SERVICES

In running service pipe from front wall to meters the following rules will apply:

Size of Opening.	Greatest Length Allowed.	Greatest Number of ¾ in. Openings Allowed.
1 inch	70 feet	1 opening
1¼ inch	100 feet	3 openings
1½ inch	150 feet	5 openings
2 inch	200 feet	8 openings

All openings in service must be equal to the size of riser, which in no case must be less than ¾ inch.

For Gas Engines.

Size of Engine.	Size of Opening.	Greatest Length Allowed.
1 H. P.	1 inch	60 feet.
2 H. P.	1¼ inch	70 feet.
5 H. P.	1½ inch	100 feet.
7 H. P.	1½ inch	100 feet.
12 H. P.	2 inch	140 feet.

Radiation of Different Sizes of Wrought Iron Pipe.

Following table gives the actual lengths of different size pipe sufficient to make ten square feet of radiation.

1 In. Pipe, 28 Lineal Ft. = 10 Sq. Ft. Radiation.
1¼ In. Pipe, 24 Lineal Ft. = 10 Sq. Ft. Radiation.
1½ In. Pipe, 20 Lineal Ft. = 10 Sq. Ft. Radiation.
2 In. Pipe, 16 Lineal Ft. = 10 Sq. Ft. Radiation.
2½ In. Pipe, 13 Lineal Ft. = 10 Sq. Ft. Radiation.
3 In. Pipe, 11 Lineal Ft. = 10 Sq. Ft. Radiation.

Greenhouse Heating.

A glass structure for horticultural purposes (owing to the manner of its construction and the materials employed) offers less resistance to the penetration of frost and cold winds than any other form of building, and necessarily requires a proportional greater amount of heat and its more even distribution. To warm such a structure properly, without impairing the quality of the air, the heat must be produced by direct radiation from an extended surface heated to a moderate degree. The heating apparatus must be so arranged as to diffuse an even heat throughout every part of the house, and must be of sufficient heating power to increase the heat quickly in case of sudden changes in the weather, and to maintain the desired temperature during the nights, when the fires are unattended. Of the various systems that have been advanced to meet these requirements, there are but three that have met with approval in general use; these I name in their order of excellence. First in the order of efficiency and economy is the system of heating by the circulation of hot water through iron pipes ranged round the house; these pipes are connected to a boiler or water heater, which heats the water and maintains the circulation through the pipes; the radiation from the pipes supplies the warmth to the house. This is the best method known for the purpose; the facility with which water absorbs the heat produced at the boiler, and by circulation, rapidly conveys it to the most distant points in the line of heating pipes, renders it a most efficient agent, and affords the means of maintaining a uniform, even temperature of any required degree throughout all parts of the house; with a mild and humid atmosphere, which is congenial to the healthy growth and perfection of plants, flowers and fruits, while the substantial, enduring and reliable qualities of the apparatus, the easy management and perfect control of heat in the house, or in several houses heated by the same fire the number of hours it may be left without attention, and the entire freedom from deleterious gases, dust and smoke, are among the advantages fairly claimed for the system.

It is so universal in its application, and offers so many advantages over every other system, that it is generally adopted, both here and in Europe, for heating plant houses of every size and description, from the small home conservatory to the largest botanical structures, and will be found in use, to the exclusion of all other methods, in the establishments of the most prominent and successful horticulturists throughout the country.

How to Figure Heating Surface of a Green House.

In figuring a Green House we have to deal entirely with exposed surface, cubic contents, rarely, if ever, being taken into account; therefore, the entire amount of glass exposed and its equivalent should be determined, and in doing this the ends and side walls should be figured just as surely as the overhead and end glass. The sides and end walls, if of wood, sheathed and papered good and tight, should be figured in the following proportions, viz: Five square feet of wall to one square foot of glass.

After obtaining the number of square feet of glass and equivalent, the next point is the proper amount of heating surface necessary, and this is dependent upon the temperature required in the green house. The following proportions of glass to heating surface will be found fully accurate.

			St.	H. W.
To a temperature of	40°	divide No. sq. ft. of glass by	9	6
" " "	45°	" " " " "	8	5
" " "	50°	" " " " "	7	4
" " "	55°	" " " " "	6½	3¾
" " "	60°	" " " " "	6	3½
" " "	65°	" " " " "	5½	3¼
" " "	70°	" " " " "	5	3

The above is based on an outside temperature of zero.

Hot Water Systems for Greenhouse Heating Under Pressure.

One of the special advantages in the pressure system is that a much greater range of temperature of water in the system can be had, and on this account, in cases of emergency, when a sudden fall in temperature must be guarded against, there will be no trouble to get the necessary heat. Another advantage possessed by the hot water system under pressure is, that any sized pipe can be used for mains and heating coils. For this system of heating wrought iron pipes are used with screw thread joints, and these are much less liable to leakage than cast iron calked joints. Then again, space is worth money in greenhouses, and heating coils of one-half the usual size that will do the same amount of heating, or more, are surely a great advantage.

With the open tank hot water system, it is not practical to carry the water higher than to a temperature of 200°, that is without pressure; but with the outlet from the expansion tank provided with a safety valve, the system may be run under any desired pressure, and in this way any desired temperature, even above 200°, can be had as readily as a temperature below 200°. To carry a hot water pressure of about fifty pounds per square inch in the heating apparatus we would have a temperature of the water in the system of 300°. It will, therefore, be seen that this is about double the temperature carried by the old style, cast iron, open tank system, which runs about 150° on the average. However, it must be remembered that any style of boiler will not answer for a closed tank system, and consequently, in selecting a boiler for such work, this point should not be lost sight of.

For high pressure hot water heating, it will be necessary to have high pressure boilers, such as are tested to stand a hydraulic pressure of at least 200 pounds to the square inch, in order to be absolutely safe under any ordinary conditions. There are many types of hot water boilers in the market suitable for this class of work, which are not only built to resist any pressure that they may be called upon to withstand, but which are constructed to heat water rapidly and econom-

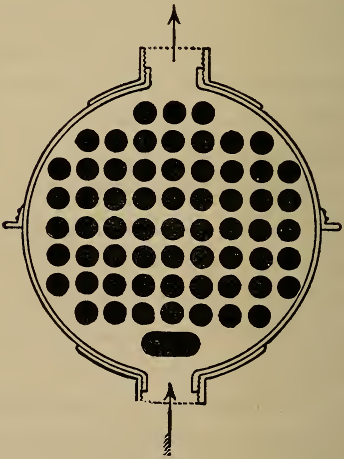

Fig. 25.

ically. One type of high pressure hot water boiler used largely in this country is the wrought iron tubular style, an end view of which is shown in illustration Fig. 25, and the special point of difference between this and the ordinary wrought iron, tubular steam boiler lies in the additional number of tubes in the former. This is done for the purpose of getting as much heating surface in the boiler as possible, and at the same time leaving ample space between the tubes for the proper and easy circulation of the water.

Another special point to which I desire to call attention in this type of boiler is the tube connections. As will be noticed by referring to Fig. 26, the return connection is near the rear end at the bottom, while the flow or outlet connection from the boiler is on the top, near the front end of the boiler, but not so much so in steam boilers. With the pipe connections arranged as shown in Fig. 26, the water must move through the greatest

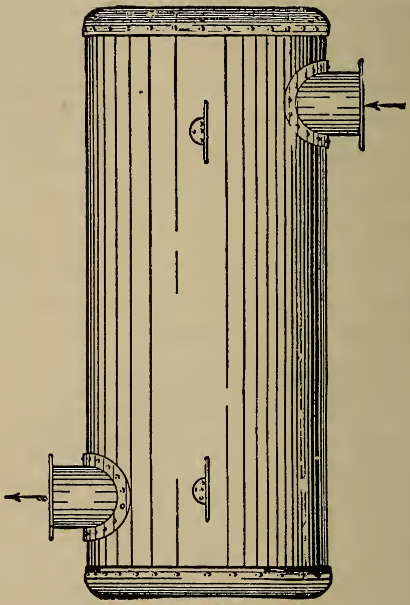

Fig. 26.

distance of the boiler, rising from bottom to top and passing from one end to the other, also entering at the coldest point and leaving the boiler from the hottest, directly over the fire in front. This disposition of the connections produces the most rapid circulation of water through the system, which always means economy in fuel. To produce the best circulation we must have the greatest possible difference in temperature between the return water entering the bottom of the boiler and the flow water leaving it at the top. These are some of the important things to know for those interested in hot water heating. It makes a vast difference how each part of a boiler is constructed.

Hot Water Heating Without Boiler Pit.

It is a general supposition among florists, and also many practical hot water fitters, that to have a successful hot water heating plant for greenhouse work the boiler must be located in a pit or cellar several feet below the heating coils. Such, however, is not the case, but at the same time a more rapid circulation of water through the heating system will be found in plants where the boilers are located below the level of the greenhouse floor. There are many locations in which it is not practicable to build a boiler pit on account of low, wet ground. It is also a considerable item of expense to build a good boiler pit even on dry ground, especially if the site is a rocky one. Therefore under such circumstances the hot water boiler may be located as shown in illustration, Fig. 27, on a level with the greenhouse floor.

A partition, it will be noticed, divides the boiler shed and the greenhouse proper, so that coal-gas, dust and smoke which may escape from the fire will be excluded from the latter. As gravitation alone is the motive power for the circulation of water through hot water plants of this kind, the one essential thing necessary will be to carry the pipes in such a manner that there will be a difference in temperature between the rising and falling columns of water. The best plan to obtain the greatest difference in temperature between these columns of water and secure the greatest motive power for circulation, is to carry all the hot water from the top of the boiler to as high a point as the building will permit of the delivery of this water into an expansion tank, as shown at T in the illustration.

This flow pipe from the top of the boiler to the expansion tank should be covered with a good non-conducting pipe covering in order that no heat may escape until it enters the expansion tank. The water is then carried from the tank at a point lower than the inlet as shown, connecting with the upper part of the bench coil and returning to the bottom of the boiler as indicated by the direction of the arrows. The vertical line of supply pipe

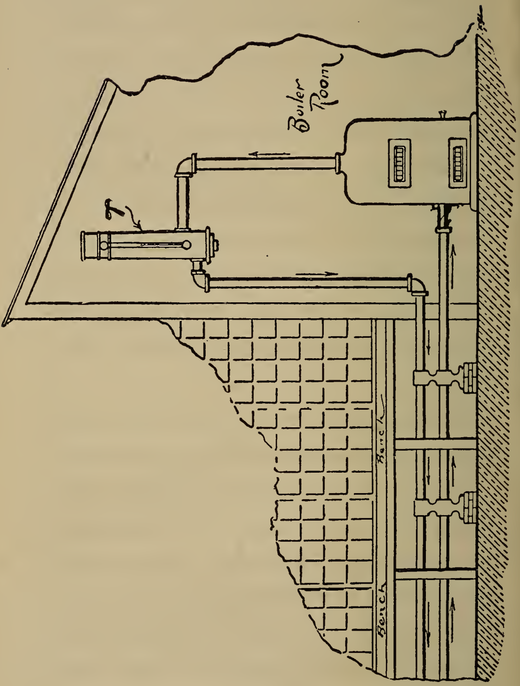

Fig. 27

from the bottom of the expansion tank should not be covered, but allowed to act as heating surface, and in some places this pipe may be situated partly in the greenhouse, passing through the boiler room partition at a point just below the greenhouse roof. When expansion tanks are located at a high elevation, as shown in the illustration, it will be found convenient to have them provided with glass water gauges, so that the height of water in the tank can be seen at a glance. Again, to fill heating plants of this kind a hose may be attached to the draw-off cock at the bottom of the boiler, when the water system is in or connected with the building. In work of this kind where four inch cast iron pipes are used in hub joints, cast iron expansion tanks will be necessary; and as they are quite heavy, it will be necessary to provide a substantial support for the tank.

It is also an important matter to have solid foundations for the boiler and all the pillars on which the pipes rest, because they are comparatively heavy without water, and when filled with water, as they are in operation, the combined weight will be considerable. Two good reasons for having solid supports for hot water greenhouse heating plants are: First, because cast iron pipe of the size used on such work has very little flexibility to it, and will therefore break before it bends when improperly supported; and secondly, as it is also important to have hot water coils properly lined and pitched, for the purpose of getting a good and positive circulation of the water; a sag in the pipes will retard the flow of water and often stop circulation entirely.

Connecting Two or More Hot Water Boilers Together..

It not infrequently happens that we find it desirable to place in one building two or more boilers coupled together for warming purposes, and, in fact, for large buildings, this plan is, without doubt, the best arrangement of the heating apparatus. For the reason that, in mild weather, the full capacity of the apparatus is not required, and although it is possible to carry a slow fire at such times in a large boiler it is much less trouble to handle a smaller size boiler and fire at a higher degree of heat. Other advantages in having more than one boiler are that in case some part of the boiler giving out in cold weather, and which might require some time to repair, in the case of having two one could be run alone until such time as the damage may be repaired without having to suffer to any great extent from cold. And, again, even without any damage to the boiler, it should be thoroughly cleaned from time to time during the winter season. This cannot be properly done unless the boiler is allowed to cool, and with a single boiler in a building with no other means of heat, it is not likely that the fire will be allowed to go out, unless by neglect, and consequently, the result is not only a great waste of fuel, but unsatisfactory work from the boiler, and much more wear to all parts of it. As I have many times said, the more clean we keep a machine of any kind, the longer it will last. This holds good, especially in a house heating boiler. With two or more boilers coupled in the same plant, it will be quite possible to keep them clean, and at the same time keep the building warm. In connecting two hot water boilers together, there are some special points which the fitter or engineer must carefully consider, and while he must not lose sight of constructing a job that will operate to perfection, he has also a proper right to carefully consider how he can do the work with the least time and material. There are also disadvantages with two boilers, and one is, that it makes it necessary to use valves on the main floor and return pipes. And as such pipes at the boilers are as a rule of large

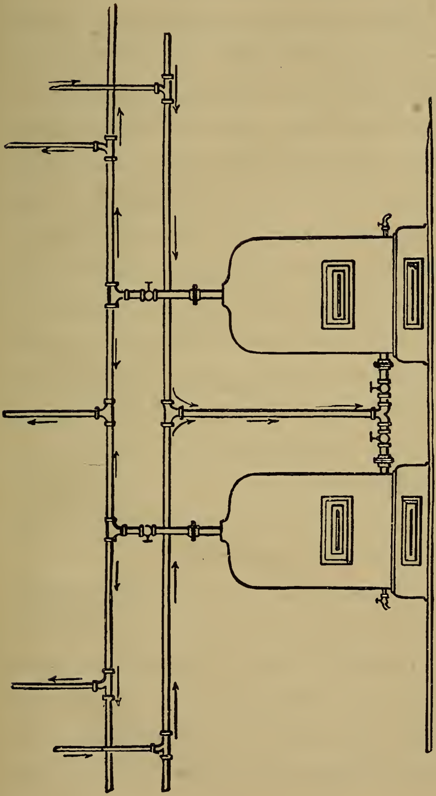

Fig. 28.

size, the natural consequence will be considerable expense for those valves. There must also be proper provision made to entirely disconnect one boiler from the other, and that means large sized flange unions or other special fittings, as shown in illustration. But there is still another point to be considered with the two boiler system, to which I desire to call attention, and that is the danger of starting up one of the boilers, that is, starting the fire and neglecting beforehand to open the valves. It is not necessary to state what the results would be in such a case. This has often happened to the knowledge of the writer, and in every case the result was a total wreck of the boiler.

To guard against such a possibility should be the aim of the fitter and one good way is to use stop and waste valves on such work, on the same order as that used in plumbing work, so that when the valve is closed on the outside from the boiler, the closing operation will open a vent-hole to the atmosphere on the boiler side of the same valve.

This will allow any pressure formed in the boiler to escape, with the valves to flow and return pipes closed, and therefore relieve the boiler from over strain. By referring to illustration Fig. 28, it will be noticed that the flange unions are placed close to each boiler on the returns; this is so that the boiler on either side can be removed without in any way affecting the other, and it will be noticed the top or flow connections are made in the same manner. In large buildings heated by the hot water system, nothing but special large sweep hot water fittings should be allowed; such fittings are shown in the illustration, and are made by a number of manufacturers throughout the United States.

With respect to the various systems of warming buildings by hot water pipes and stoves, and as economy is the order of the day, I may only mention the present practice of our horticultural gardeners who have entirely abandoned the furnace and hot-air flues for the hot water apparatus.

The furnace and hot-air flues were comparatively cheap, so far as first cost was concerned, but not only was the cost of working in the consumption of fuel double, but they were a complete failure; for most people know that hot-air will get cold before reaching the further end of a greenhouse; therefore, at the furnace end of a greenhouse it would be too hot, and at the further end it would be too cold; whereas in the hot water warming, every part of a large building can be made of the same temperature, as water will circulate in pipes a quarter of a mile with one boiler, and a much less cost in fuel.

Although the principle of hot water circulation in pipes was known to a few of the ancient philosophers, yet we may say that the practical mode of working and fixing hot water apparatus for warming buildings is a modern invention of about 70 years standing.

Materials for Brickwork of Regular Tubular Boilers.

Single Setting.

Boilers.		Common Brick.	Fire Brick.	Sand, bushels	Cement, Barrels.	Fire Clay, Lbs.	Lime, Bbls.
In.	Ft.						
30 x	8	5200	320	42	5	192	2
30 x	10	5800	320	46	5½	192	2¼
36 x	8	6200	480	50	6	288	2½
36 x	9	6600	480	53	6½	288	2¾
36 x	10	7000	480	56	7	288	3
36 x	12	7800	480	62	8	288	3¼
42 x	10	10000	720	80	10	432	4
42 x	12	10800	720	86	11	432	4¼
42 x	14	11600	720	92	11¾	432	4½
42 x	16	12400	720	99	12½	432	5
48 x	10	12500	980	100	12½	590	5¼
48 x	12	13200	980	108	13½	590	5½
48 x	14	14200	980	116	14½	590	5¾
48 x	16	15200	980	124	15½	590	6
54 x	12	13800	1150	108	13¾	690	5½
54 x	14	14900	1150	117	15	690	6
54 x	16	16000	1150	126	16	690	6¼
60 x	10	13500	1280	108	13½	768	5½
60 x	12	14800	1280	118	14¾	768	6
60 x	14	16100	1280	128	16	768	6½
60 x	16	17400	1280	140	17½	768	7
60 x	18	18700	1280	148	18¾	768	7½
66 x	16	19700	1400	157	19¾	840	8
72 x	16	20800	1550	166	20¾	930	8½

Materials for Brickwork of Regular Tubular Boilers.

Two Boilres in a Battery.

Boilers.		Common Brick.	Fire Brick.	Sand, bushels	Cement, Barrels.	Fire Clay, Lbs.	Lime, Bbls.
In.	Ft.						
30 x	8	8900	640	70	9	384	3½
30 x	10	9600	640	76	9½	384	4
36 x	8	10500	960	84	10½	576	4¼
36 x	9	11100	960	88	11	576	4½
36 x	10	11800	960	95	12	576	4¾
36 x	12	13000	960	104	13	576	5¼
42 x	10	17500	1440	140	17½	864	7
42 x	12	18600	1440	148	18½	864	7½
42 x	14	19900	1440	159	20	864	8
42 x	16	21200	1440	168	21	864	8½
48 x	10	21400	1960	170	21½	1180	8¾
48 x	12	22300	1960	178	22⅓	1180	9
48 x	14	23900	1960	190	24	1180	9½
48 x	16	25100	1960	200	25	1180	10
54 x	12	23300	2300	186	23⅓	1380	9⅓
54 x	14	24800	2300	198	25	1380	10
54 x	16	26300	2300	210	26⅓	1380	10½
60 x	10	22600	2560	180	22½	1536	9
60 x	12	24800	2560	198	25	1536	10
60 x	14	26800	2560	214	27	1536	10¾
60 x	16	28900	2560	230	29	1536	11½
60 x	18	31000	2560	248	31	1536	12½
66 x	16	33100	2800	264	33	1680	13¼
72 x	16	34000	3100	272	34	1860	13¾

INDEX.

INDEX—Continued.

Identification.

Name ....
Address ....
In Case of Serious Illness or Accident, Telegraph ....
....

How Easy to Forget

Size of Hat......... Gloves ....
Size of Collar........ Cuffs ....
Size of Shirt........ Shoes ....
Size of Hosiery...... Underwear ....
Size of Jumper...... Overalls ....
Make of My Watch........................
No. on Case of Watch....................
No. of Works of Watch..................
Watch was last Cleaned..................
My Weight was...........................
And My Height............feet......inches.
On ....
No. of My Bank Book is..................
No. of My Telephone.....................
Meeting Nights ....
At ....